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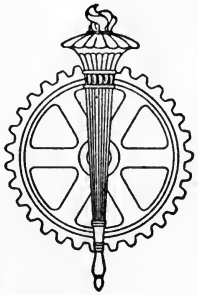
PRODUCTION FACTORS

IN COST ACCOUNTING AND WORKS MANAGEMENT

BY

A. HAMILTON CHURCH



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INTRODUCTION

Mr. Church's study of the Distribution of Expense Burden in manufacturing establishments, especially machine-tool using and machine-building plants, is widely known as one of the very important contributions to exact knowledge of costs of production. His first contribution to take authoritative rank and permanent standing in the literature of the subject appeared serially in THE ENGINEERING MAGAZINE from July to December, 1901, and as reissued in book form has become standard in libraries of works management and industrial engineering.

In the discussion now presented (which also was first presented as a series of articles in THE ENGINEERING MAGAZINE, running from October, 1909, to April, 1910), he extends the idea of accurate allocation of costs much further. He proposes, indeed, a new way of looking at the whole problem of manufacturing expense. His purpose is to avoid the averagings and approximations of a mixed expense account, now commonly in use, by recognizing from the very outset all the important "factors" in production, and segregating continuously the charges belonging to each. Many such factors can be recognized, he maintains, quite as distinct and determinable as the wages factor, and reducible to unit values which may be applied directly to the product they serve.

The demonstration is thorough, practical, concrete enough to enable the cost accountant or manager to apply it to his own case, yet not lacking in the broad statement of principle that applies to all cases. It will be followed with interest by all who are associated with the investigation of the real facts of production costs.

THE EDITOR.

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ORGANIZATION BY PRODUCTION FACTORS

Chapter I

THE DEFINITION OF FACTORS OTHER THAN LABOR

THE method of organization by production factors is not so much an addition to the innumerable varieties of cut and dried "systems" as a new way of looking at the facts of production.

From the earliest days of manufacturing there has grown up a custom of considering labor as the main and only direct item in production, and of expressing all other expenditure in more or less vague percentages of wage cost. The fact is, however, that labor, while always important, tends to become less important relatively to other items as the progress of organized manufacture develops and the use of specialized and ex-

pensive mechanical equipment increases. Very few concerns have come to grief by ignoring labor costs, but many have passed into the hands of receivers by ignoring the relative importance of the other factors of production.

It is time, therefore, to see whether some fundamental change in the point of view commonly taken of production is not both possible and desirable—whether the older point of view, in which a large number of heterogeneous activities are grouped round the central idea of wage-labor, is not capable of replacement by a newer one, in which the greatest possible number of separate factors are recognized, kept distinctly and separately in view, and the bearing of each on cost of production is treated individually. It cannot be denied that this is a decided wrench from ordinary custom and routine, and that to many it will seem unnecessary. Its chief merit, however, may be considered as tending both to greater accuracy and a nearer approach to the recognition of actual facts. Once the prepossessions due to the older method are removed, it will also be seen to have the character of greater simplicity, both in the way in which it enables the facts of

production to be grasped and in the working up of data into the form of costs.

It is preferable to consider this as a matter of organization and not merely as a matter of costs. The great value of accurate cost accounts lies in the way in which they represent the results of organization—summarizing a multitude of facts far too numerous and complex ever to be ascertained without very careful record. But the best system of costs cannot do more than give results severely conditioned by the form of the organization. No existing system of costs is worth anything by itself; the data it provides must be read in connection with a knowledge of the form of the organization—except, of course, when "prime" or "flat" costs alone are being considered. The proof of this statement will be recognized when it is considered that no two costs from different works can be compared, unless the method on which the indirect charges are estimated is identical in both works—a consideration that shows how very artificial and arbitrary much of even the most highly organized cost accounting really is.

This artificial and arbitrary character is inseparable from existing methods, because

these latter do not attempt to disentangle the facts of production (except wages cost) but run them all together, with the result that they appear as a blurred or confused picture without any significance—without, indeed, any real meaning. So much is this the case that great difference of opinion exists as to the way in which indirect charges should be treated, a very common idea being that their percentage to wages should be artificially maintained as steady as possible; and all sorts of averaging methods, "suspense accounts" and the like, are made use of to keep these percentages from fluctuating. Yet it is just as irrational to reduce many of the factors of production to an "average" as it would be to throw all wages into a common account and spread them over work on a similar averaging plan.

It has been said that the best system of costs needs to be read with a knowledge of the organization—whenever we try to go beyond flat costs. It is probably the practical realization of this that has made many employers doubt the value of highly organized systems and content themselves with very elementary information as to bare wages and material costs. With something certain

to go upon, they argue, practical intuition will do the rest. Elaborate methods of connecting charges with costs, being for the most part based on averages, throw no light on individual jobs, and for all practical purposes such charges can be ascertained roughly and broadly at infrequent intervals, kept in the head, and mentally added to the prime or flat cost of a job at any time when the latter is under discussion. It must be admitted that there is a good deal of justification for this point of view.

The truth is that a more extraordinary jumble of figures that have no connection with each other, and no significance in relation to any particular job, cannot be found than the so-called expense accounts of most manufacturing businesses. Very few persons, even of those who use them daily, realize what they mean practically. No one, commonly, has the least idea how they are likely to be affected by an expansion or shrinkage in the volume of work, and if so affected, what deductions can be safely made from their rise or fall. Yet, unless their existence is a real benefit and has a real significance, their collection and working up is a wholly idle expense. The heterogeneous

items of expense accounts have no relation to each other, any more than they have, directly, to labor itself. The most cunning and involved system in the world cannot make them have any relation to each other or to labor. Any attempt to do so, and to express them in the form of percentages on labor, really "darkens counsel" and performs the very dangerous service of representing something to be a useful fact which hardly attains to the dignity of a fact at all.

But though these heterogeneous items of expense have no relation to each other or to labor, many—in fact, most of them—have a very real and intimate relation to production, and to cost of production. Instead, therefore, of laboriously collecting them together and trying to fit them by main force into some artificial relation to labor, it may lead to altogether new results if we keep them separate—if we cease to jumble together the cost of coal, the depreciation of machinery, and the rent of land or buildings, calling the aggregate total "expense," but rather take the point of view that each of these diverse items of expenditure has its own special influence and its own true incidence on the cost of production, and see whether any practicable

method suggests itself of representing that special influence in the system of registering representative facts that is called "costs."

WHAT IS A PRODUCTION FACTOR?

A Production Factor may be defined as any expense that has a *definite* relation to cost of production. It is not pretended that each and every item of expense can be reduced to production factors, but it will be seen that a very large and important number of them can be so reduced. The principle of "Organization by Production Factors" is to keep things in sight that are generally covered up, disguised and lost to view, and to observe the facts and phenomena of production along natural lines, as distinct from arbitrary and artificial lines.

Hitherto the only recognized production factor has been labor, as expressed in wages costs. (To simplify the argument all consideration of material is omitted—it does not affect the question of process work at all, and our discussion is confined to this for the present.) Between the cost of a piece of work and the wages paid for the operations performed upon it the closest connection has always been realized. In certain kinds of

work, as, for example, a man performing a repair job on some one else's premises and with his own tools, labor is the *only* factor of production.* But in proportion as labor finds itself situated in the midst of a highly organized modern works, so it ceases to be the only factor of production, and in the extreme case of a roomful of nearly automatic machinery, may cease even to be an important factor.

In the case of the highly organized modern works, what are the other factors of production? When we have ascertained this and have placed and enumerated them, it will be seen that the other factors are just as definite in their incidence on work, and just as important to keep in close scrutiny, as labor itself. We shall see also that this organization by production factors has important indirect benefits in matters of comparison, of control, and of maintaining a high pitch of efficiency.

The mind readily grasps the idea that when a man is at work machining a large

*Even here a rigidly careful analysis may detect other factors—as, from the workman's point of view, the supply and repair of his tools, risk of the work, risk of idleness between jobs; from the employers', interference with other use of the premises, time and cost of securing the workman, of inspection, etc.—THE EDITOR.

casting, the man's wages are, so to speak, passing into that casting and being absorbed therein. It is readily seen that this is a case of "productive" expense—the work of the man is actually going towards making the thing worked on more valuable. This picture is so familiar and is so easily understood that it seems to be like no other element of production. Labor, in short, seems to be *the* production factor.

Actually, however, as is implied in all systems of "distributing" indirect charges, much more than labor-cost is passing into the casting. The wear and tear of the machine tool, every stroke or revolution of which is shortening its life and rendering it necessary to replace it one day, is also passing into the casting. The interest on the value of the machine tool, the cost of the power that drives it, and the cost of keeping it in repair from day to day, are also items which are passing into the cost of machining the casting. That this is so will generally be admitted, yet the picture is not so definite as in the case of labor. The wages of the man are taken out of the cash box, whereas the cost of the other items cannot be pictured in anything like such a definite way. Fur-

ther, there is a difference between labor and many other items of productive expenditure. The cost of labor can be shut off suddenly and completely. Most of the other items are not so terminable. Their cost must be met whether work is being done or not. It is perhaps this difference in permanence that has been the determining feature in placing labor in one class and all other expenditure in another and less distinct class. When it is admitted that labor is, also, by far the largest *single* class of expenditure, the reason why it has eclipsed and obscured all the other items may be understood.

The fact that one item of expenditure, and that often the largest, can be cut off when it is no longer needed, and that other items are either quite permanent (as in the case of rent) or merely diminishable (as in the case of power) is not, however, of the fundamental importance that it seems. It is a distinction, but a distinction neither of great interest nor of great significance. In ordinary expense treatment, where no provision is made for taking up the heavier incidence due to slack production, the averaging method appears to meet the circumstances—but it does so merely by slurring over differences which

should be brought to light, and by losing sight of realities which should be kept steadily in view.

When, however, we come to consider the very varied functions that costs discharge, we shall see that the averaging method produces a comfortable uniformity at the sacrifice not only of accuracy but of a great deal of useful information. It may simplify the argument at this stage, however, if we confine our attention to the case of a concern working full time, leaving till later the problem of slack production.

When working full time the suggested difference between labor and other expenditure in respect of permanence disappears. The cost of work is then made up of various factors—all of them functions of time—labor being the largest single item in most cases, and the others perfectly independent not only of labor but of each other. Under these conditions our conception of labor as the main direct factor in production becomes usefully expanded, and the term "production factor" is made to include many other distinguishable expenses, all of which are now jumbled together in the general term "indirect expense."

ANALYSIS OF THE ACTIVITIES OF PRODUCTION

Much of the confusion surrounding the subject of expense has arisen from the fact that in most cases the manufacturer does other things than manufacture. He fulfils other functions, and though these functions are undertaken by him only with a view to the main object—viz., manufacturing—yet they are in their nature clear and distinct from manufacturing. No object is gained, but on the other hand many disadvantages are suffered, by mingling and confusing these other functions with the manufacturing organization pure and simple. Looking at the question from the point of view of costs, not only is no object gained, but an entirely false view is very often given of the whole position, leading to financial misconceptions that are always perilous and may easily be disastrous.

In a series of articles by the present writer, published in THE ENGINEERING MAGAZINE and recently issued in book form,* it was pointed out that the "analysis" of expense burden or indirect charges into classes of expendi-

*The Proper Distribution of the Expense Burden. THE ENGINEERING MAGAZINE, New York and London.

ture was, in fact, an inversion of the natural process. Things which have no natural relation to each other should not require analysis; they should never be mingled at all. The point of view then presented has been widely admitted to be the correct one, and it is the object of the present series of articles to carry the process a stage further and to show not only that the incidence of expense burden *can* be connected with actual jobs, but to demonstrate that most of the component items are perfectly legitimate and separate charges for "services" rendered to production, just as labor is a "service" rendered to production. The arguments offered in the earlier series of articles are not affected by this expansion of the point of view. They are, in fact, reinforced by a clear recognition of the underlying principles of productive activity.

Hitherto it has been customary to regard the questions of organization, and therefore of costs, from the point of view of an enterprise in full swing. It has been usual to enter, figuratively speaking, a works or factory, to contemplate the varied activities going on therein, and to try to "analyze" these activities into groups, so that some guide to

the maze can result. This, it may be said, is the natural method of the accountant, but it should not be the method of the organizer. Where a large number of facts have to be co-ordinated, many of them are likely to be roughly and forcibly fitted into groupings to which they scarcely belong. That this is what actually happens may be shown by comparing two or three schedules of classification of "indirect expenses" or "establishment charges," as presented by different writers or as in practical use in different works. Commonly they agree neither in amount of detail nor in grouping, and this is simply because they are regarded as abstractions—as inconvenient items which it is necessary to do something with; but what that something may be is not a matter of extreme importance. Where everything is a compromise, extreme accuracy is indeed impossible.

The error which dominates and vitiates all the usual and popular methods of dealing with indirect expense is simply "analysis." That is the rock on which they all founder. For the purposes of the accountant this analysis is sufficient, because the accountant is concerned neither with the efficiency nor the improvement of production.

It does not matter greatly to him whether a particular item of expense is due to inefficient power distribution, or to worn-out machinery, or to buildings imperfectly adapted to their uses. To him an expense is an expense; but to the production engineer it may be more than an expense—it may be a revelation. Yet, as long as we persist in looking on all the activity and all the expenditure going on in and about a works as due to production, so long will the accountant's point of view necessarily hold the field. As long as we shut our eyes to the fact that actual production is the last organization in a chain of separate organizations, so long will the present confused ideas about indirect expenses or establishment charges hold their ground unshaken.

It is perhaps only those who have had the opportunity of observing manufacturing industry in its primitive forms, as still carried on in some parts of Europe, who will be able at once to recognize the difference between the main function of the manufacturer in producing some specific product and his *subordinate* but still very distinct functions preceding and accompanying his manufacturing function. In a large modern manufacturing

concern these functions are, in fact, not easy to recognize without considerable study; but in the progress from the most primitive forms of industry up to the modern scale of manufacturing activity, it can easily be seen how one after another of these functions is assumed and incorporated with the direct productive function.

It has been said, above, that cases exist where labor is the *only factor* of production. It may also be said that these are cases where the productive function exists unconnected with any subordinate function. Where an independent worker is on some one else's premises, doing work either by day or piece, with his own tools (as, for example, a jobbing carpenter), he represents production in its simplest form. But the moment we pass beyond this stage other considerations come into play. Supposing that he works on his own premises; the element of rent at once enters into the calculation. For each kind of work there is a limit beyond which the worker cannot afford to pay more rent. A stage further is the use of power. This, too, may be rented at so much per horse power, and the question of a cheaper or dearer source of power may make all the difference in the

world to the isolated worker. It is perfectly easy to recognize that two variable elements have now entered into production, entirely independent, one of the other, but each having an important bearing on economy.

Yet these elements do not affect the function of the worker as producer. He is still a producer only, and has not assumed any other function. He can change his workshop, and he can change his source of power, because he merely pays fixed sums for the "services" of floor-space and power which the landlord and the power company render to him. (We are assuming one man and one machine throughout this argument.)

Now let us suppose that his ambition increases. He is not satisfied with the charge made to him for power. Some one suggests to him that he would do better for himself to put down a gas engine and supply himself with his own power. By doing so he immediately passes beyond the simple productive function and assumes a new function—that of a supplier of power. Let us therefore look into this development closely, because it represents in a very small and incipient degree the complication of functions found in a large modern manufacturing enterprise.

Up to that point the production factors entering into his output were three—viz.: (1) his own time, (2) his rent, (3) the cost of his power per horse power. Each of the two latter is expressible as a distinct element in the cost of his product. Obviously, it would be senseless to lump rent and power together and express them as a percentage of wages cost. In this single case it is easily seen to be senseless, though in more complex conditions the same kind of consolidation of things that have no real relation is done every day.

When he has installed his gas engine the problem takes on a more modern and familiar aspect. It has become relatively complex —if we like to make it so. What, we may inquire, is the proper method of arranging his cost accounts? The familiar way would be to analyze his indirect expenses—so much for rent, so much for gas, for lubricating oil, for ignition tubes, for repairs to the engine (which we may imagine to be a second-hand one in poor condition, requiring frequent repair); to throw all the separate items into one "burden" or "establishment charge," and to allocate it as a percentage on wages cost by one or other of the well-known and

much debated methods. In other words, we confuse his function as producer with his function as supplier of power, and having mixed them up inextricably, we contentedly express the result of the jumble as a percentage on wages or time.

The alternative to this is perhaps obvious. It is to keep the two functions he has assumed perfectly distinct. Instead of consolidating his indirect expenses, he would do much better to preserve the more primitive form of his costs, and continue to recognize three factors as before—viz.: Time, rent and power. In order to do this satisfactorily he need take no more trouble. All he requires is to keep all his expenditure on power (that is, all the cost entailed by his function as supplier of power) separate and distinct from his other expenditure, and to express it *not as a percentage on time, but as a rate per horse power consumed.* He will then obtain his power factor exactly in the same form as he originally had it when he rented his power, not from himself, but from a supply company. Notwithstanding his new function, his costs will be in the same form as before, and his records directly comparable under either *régime.*

ADVANTAGES OF PRODUCTION FACTORS.

The three factors of his production, being still separate and distinct, will afford him much food for thought. We will assume also that he is in touch with brother workers, broad-minded enough to discuss between themselves all points of their work with a view to improvements and economies, and we will ask which method—the "averaging" percentage method, or the "production-factor" method, will give the best basis for intelligent discussion, and for recognition of actual facts.

If three or four such "little masters" may be supposed to meet together to talk over their methods and compare notes as to their relative efficiencies, it is obvious that if each of them knows only two facts about his production—viz.: (1) his labor cost; (2) the percentage of his total expenses to his labor cost—they will not be able to compare results favorably, for even though one of them discovers that his percentage is higher than that of his friend, he will not be enabled to say why. But on the other hand, if the three production factors so far introduced are kept entirely distinct, then intelligent comparison

becomes at once possible. The rent factor of one is perhaps higher than that of another. The power factor of a third may be greater than that of his fellows. The introduction of the gas engine, for example, when reduced to a power factor, may easily be seen to be a mistake, whereas if treated as an ordinary item of expense that unpleasant truth would have had a strong tendency to conceal itself.

Again, our suppositious worker may rent a piece of ground and erect upon it an iron workshop for himself. This introduces a further complication and is another step toward the complexity of modern manufacturing concerns. In addition to his purely productive function, he has already introduced another function, that of supplier of power, and by this new step he introduces yet another, that of owner of buildings. He still pays rent for his ground, and has not yet become a landowner, but his new function must obviously call for representation by a "buildings factor" in addition to the power factor already established. For it must not be forgotten that this, too, may be a retrograde step. When all his transactions with regard to his building are collected to-

gether and summed up and translated into a building factor, they may collectively prove to be more costly than the simple rental plan was originally. The cost of repairing, painting, and lime-washing, together with the interest on the cost of the building, are, of course, components of this new factor.

Obviously, the rise and fall of either the buildings factor or the power factor are entirely independent of each other. By no stretch of imagination can they be considered as having any interrelation. Consequently, their relations with the labor factor are entirely individual. To lump them together and express them as a percentage of wages cost is seen to be a mistake, *for whatever significance they may present when kept apart is demonstrably lost when the two sets of figures are mingled.*

If it is easily seen that his prime cost should not suffer because he has made an error of policy in becoming a building-owner —if it is admitted that prime costs should always be distinguishable from all other elements for the sake of clearness and comparison—then the way is prepared for the argument that it is equally wrong in principle to throw all expenses other than prime

cost into a common indistinguishable fund that may easily become a perfect well for the hiding of errors in policy. Excessive labor cost is a well-defined offence against the rules of good management, but how many have inquired as to an excessive power factor or an abnormal buildings factor? It is true that for the most part (but not always) labor cost is by far the greatest *single* factor of production. But the aggregate of the other factors is nearly always equal to, and sometimes exceeds, the labor factor, without any standard of comparison and control being possible under existing methods of organization.

The tendency of modern business is towards standardization in most departments, but in organization the process has not even been begun. The cry that each business demands its own special organization is about as true as that each machine shop demands its own special tools. It may demand *some* special tools, but standard planers, lathes, and milling machines will probably form the larger bulk of its equipment. The advantage of regarding production from the point of view of its component factors is that it will build the great framework and structure of all

similar business in the same way. It will standardize a large number of elements that are now extremely varied and even fanciful, and it will enable comparisons to be made that are not at present possible.

No one at the present time can say what is a standard buildings factor proper to a machine shop, a foundry, or a rolling mill, and this implies that no one is in a position to say that this or that particular instance is an example of inefficiency when it is discovered. In electrical power generation great benefit has resulted from the frequent publication of figures representing the production costs per unit of power delivered at the mains, thus stimulating a healthy rivalry between stations to keep a close watch on their expenses. The comparatively few factors entering into central-station work have made this easily possible, but though in the case of manufacturing enterprises the factors are more numerous and complex, the benefit to be obtained by defining and keeping those factors separate would be even greater.

From the illustrations given the outline of the production-factor method of organization will now be seen. Its controlling principle is not the "analysis," but the *keeping separate,*

of various functions filled by the manufacturer which are not in themselves purely manufacturing processes. There is no very subtle or involved idea in this. It is a simple recognition of facts that, somehow or other, in the course of progress toward highly organized manufacturing have been overlooked and forgotten. The functions of the manufacturer as landowner, as landlord of buildings, as supplier of power, and many similar things, have nothing to do with his manufacturing function. It follows that by keeping them separate we have a strong chance of coming ultimately to the view of the facts relating to production unmixed with elements that do not belong to them. That will be a clear gain, but it will be no less important a gain if we are enabled to establish a basis of comparison for the non-manufacturing functions.

Taking the questions of buildings and power alone, such problems as the relative efficiency of different methods of construction, of whether it would pay to rebuild particular shops, of comparison between different forms of power generation and distribution, of the scrapping and replacement of power plant, would have valuable light

thrown upon them. Comparison with other works and other localities would be facilitated. A whole group of important items now entirely hidden and obscured by consolidation with each other would be brought under discussion. And, last but not least, these items would cease to obscure the real facts about manufacturing costs, and wherever inefficiency existed it would be placed on the right shoulders.

Before going into detailed explanation of Organization by Production Factors, it will be desirable to consider the question of what is meant by the term "organization" and the term "costs." As to the latter, especially, some confusion of thought exists, because it is hardly recognized in sufficient degree that there are several quite diverse objects sought to be attained by costs. They are used for several different purposes, and each of these purposes requires them in a different form. My own view is that it is the business of organization to regulate production, and the business of costs to represent facts and nothing but facts.

This statement may seem to be a truism, but unfortunately many people believe that costs may be usefully manipulated and

twisted and averaged so that they cease to represent what actually happened and come to represent what in the opinion of their manipulator ought to have happened. A simple illustration of this is the argument not infrequently met with, that where machine rates are in use a job done on a large heavy planer that could have been done on a lighter machine should not be "penalized" by bearing the burden incident on the large machine. It would be just as proper to insist that where premium work is in use a piece of work should always be costed at its lowest recorded rate of production. The fact is that costs must always be read, as the artist is said to have mixed his colors, "with brains." But as a prelude to an intelligent reading of them, an unflinching representation of facts —of what actually did happen—appears to be a fundamental necessity. In the next chapter the bearing of production factors on the different uses of costs will be further considered.

Chapter II

PRODUCTION FACTORS AS RELATED TO COST ACCOUNTS AND STAFF

THE object of organization is to determine the ways and means of efficient production; the object of cost accounts is to register and record every stage and step of production as it actually happened. It is very necessary to insist strongly on this latter definition. Costing should be registration of production—events that have actually happened—it should be nothing else. But when such facts have once been faithfully and accurately recorded, then they may be interpreted in several different ways, according to the needs and the point of view of the person interpreting them.

The necessity for insisting on the apparently elementary statement that costs are records is justified by the tendency of some writers to define estimates as costs. Even so eminent an authority as Mr. Harrington

Emerson has recently stated in THE ENGINEERING MAGAZINE:*

> There are two radically different methods of ascertaining costs, the first method to ascertain them after the work is completed, the second method to ascertain them before the work is undertaken.

I venture to think there is a confusion in nomenclature here. One cannot "ascertain" a cost in advance, although it may be perfectly feasible to "estimate" it more or less closely. As a matter of fact, in this particular instance Mr. Emerson's estimated costs are afterwards checked and compared with ascertained or actual (i. e., real) costs, and the discrepancy between the two is interpreted as "waste."

It is very important that costs should not be regarded as something that may be manipulated, nor should they be thought of as representing anything but the cold truth, however unwelcome that may be. Unless we have confidence that our costs do, in fact, truly represent what was happening in the shops on a given occasion, it is possible neither to compare them with estimates of

*Efficiency as a Basis for Operation and Wages, Chapter VII, page 102. Published by THE ENGINEERING MAGAZINE, New York and London.

what they should have been, nor to deduce valuable lessons for the future from them.

But if our costs represent the actual facts of production and the actual results of our form of organization, then there are several uses which may be made of them. Amongst these may be mentioned:

1. The financial or accountancy use, as showing how money was expended.

2. Comparison with estimated results, as in Mr. Emerson's method, the discrepancy between estimated and actual results being regarded as "preventable waste."

3. The technical use, showing the cost of every process on every part, enabling a close check to be made upon efficiency of production.

4. Use as a basis for fixing premium or bonus rates.

5. The commercial use, as a basis for fixing remunerative prices, and for selecting that class of product that can be most profitably manufactured.

The first of these uses—the accountancy use—demands very little detail. Its requirements are met by broad classifications into "productive" and "non-productive" expenditure," and the subdivision of these classifi-

cations is rather a matter of fancy than of real use. Elaborate scheduling of expenses is not infrequently undertaken, without any real use being made of the figures. The proper attitude of the accountant towards costs should be that of regarding them as details of "control accounts" with which their aggregate totals should agree. He should not attempt further classifications that can be more efficiently obtained from the detailed costs themselves when interpreted by those technically competent to do so.

The remaining uses of costs all depend upon accurate determination of the fractional costs of parts. It would be an excellent thing if it were established as a fundamental axiom of cost accounting that *the cost of a machine is the aggregate of the costs of every process on every part, plus the value of the material.*

A few years ago this would have appeared an impossible and idealistic definition. The modern tendency to plan out, schedule, and specify everything in advance is rapidly making the "process" the starting point of all organization, and therefore necessarily of all costs. It is here that we come directly into contact with the question of production

factors. Material presents but few difficulties. Its cost is easily ascertained. But before we are in a position to give the cost of every process on every part it will be necessary to determine, first, what we mean by the cost of a process, and secondly, how far we can express our meaning in actual figures. It may be well to put this in the form of a definition, as follows:

The cost of a process is the aggregate of direct labor cost plus the cost of the various indirect "services" to production (or production-factors) which are necessitated by the form of the organization.

Whether or not we can succeed practically in regarding all shop expenditure in the light either of direct labor or of "services" rendered to production, it is the object of these studies to examine; but, assuming for the moment that it can be done, it will be admitted that process cost as defined above is necessarily the proper basis on which total costs should be built up. It will be seen that the cost of a process on a single part becomes a perfectly definite and tangible thing and can be recorded as such. The tendency to regard burden or indirect expense as something that should be "averaged," manipu-

lated or juggled with, disappears. But there will still be left, and under any possible system of organization and any possible method of costing, there always will be left, the problem of the "penalized" job.

FLUCTUATION IN DIRECT COSTS.

By a "penalized job" is meant a piece of work that from exigencies of the moment is done by a more expensive man or on a more expensive machine that normally needful. Many persons think that an ideal system of costs should represent the cost of such a job *as it ought to have been* rather than as it actually was. The point is an interesting one, and obviously needs to be discussed and cleared out of the way before we can claim that any proposed system of costs is truly representative of facts.

It must not be forgotten that the "penalized job" always represents inefficiency of organization. Mr. P. J. Darlington has recently* put the case for the penalized job in these words:

> A very large proportion of machine work is done on tools much larger than necessary for each opera-

*Principles of Works Management. THE ENGINEERING MAGAZINE, April, 1908, p. 65.

tion. This is usually for good practical reasons, such as to keep otherwise idle equipment and operators profitably employed . . . evidently indirect cost must be based on the indirect rate *normal* to the operation rather than on the rate of the tool on which the work happens to be done.

Now if this is a fair statement of the case, if a large proportion of processes are carried out under inefficient conditions, then it would seem that the only thing to do is to represent, in the costs, what actually happened. If owing to the equipment being out of proportion to the work done on it, systematic inefficiency results, no amount of explaining the matter by reference to "good practical reason" will either bring the equipment into closer harmony with the work, or reduce the actual cost of the processes as carried out. Whether a more expensive man or a more expensive tool was used than actually necessary, it seems a very dangerous proceeding to misrepresent in the costs what actually did take place. Once the principle of "what ought to have been" instead of "what was" becomes introduced into records of any kind, they rapidly degenerate to the value of waste paper.

It is admitted that the question presents

peculiar difficulties. In a shop wherein large machines were frequently used to do the work of small ones, several things might be done. (1) The "normal" instead of the actual cost (if it were known) might be charged in costs and the balance placed to an "inefficiency account." (2) The large tools might be sold and replaced by others better adapted to the work. (3) The large tools might be left, and new ones purchased suitable to the general run of the work. Let us glance at these alternatives.

(1) Charging the "normal" rate instead of the actual in the costs would be a very dangerous proceeding, and would give no new information as to the condition of inefficiency. It is true that the "inefficiency account" would call attention to the condition obtaining in the shop, *but not more urgently nor more forcibly* than would the higher process costs on the regular method.

(2) It might be impossible to part with the large tools, and in such a case the inefficiency remains as a regular feature of that particular shop's working.

(3) If the old tools were left and new ones added, the general efficiency would not be raised, because the idle burden on the old

tools would continue to fall on the shop as a whole.

This matter has been discussed at some length because it involves an important principle, viz., whether costs shall be actual records or only guesses and informal memoranda. In the case cited it is obvious that inefficient conditions exist in the shop, and nothing can remove them. The only question is whether the costs shall reflect exactly what happens, or whether some attempt shall be made to make things "look pretty" by covering up part of the truth. In view of the very grave dangers attending the permission to vary the truth of such records, it does not seem that the advantages to be gained by smoothing down and rounding off "penalized" jobs are worth the trouble and risk, even were it proper from a theoretical point of view so to treat them.

That it is not proper from a theoretical standpoint to tamper with and adjust costs under such conditions there can be no question whatever. If a higher priced man than necessary is given the job just because he happens to be there, his wages pass into and become part of the cost. Very few persons would have the hardihood to suggest that

wages should be adjusted and averaged. But it is equally true of a machine. The moment we put a machine in work the production-factors of that machine are passing into the cost of the work. We are using up the machine and using up the power that drives it just as well on a small job as on a larger, and probably in no less degree. Machine rates differ in proportion as machines are large, heavy, and costly, or small, light, and cheap. If we set the larger of the two in motion, on whatever job, it is just as fair that the job should bear the cost, as it is fair that the job should bear the cost of the higher wage rate of an expensive man.

It does not seem worth while to depart from the actual representation of facts to obtain—what? Estimated or "averaged" costs on the one hand, and on the other an "inefficiency" account which would teach less clear lessons than intelligent reading of the actual process costs themselves. For the present, therefore, and until there is some new method of representing departmental inefficiency as expressed in production factors (or any other method that attempts to connect real manufacturing expense with work done), or even in prime or flat costs, we must

be content to see that inefficiency expressed in a higher cost of the actual job done under the inefficient conditions.

FLUCTUATIONS IN BURDEN.

While it does not seem proper to relieve "penalized" jobs of the extra cost entailed by the conditions of inefficiency under which they have been performed, the limits within which such costs will fluctuate are not very great. No previous planning will reduce the actual cost, though it may help to explain the reason for any small increase. But when we come to consider fluctuations in burden or establishment charges, altogether different possibilities are found to exist. The problem of violent fluctuations in burden has always presented peculiar difficulties, and has afforded the best arguments for the school of thinkers who support the principle of "averaging." A question frequently asked, for example, is whether building repairs should be charged in the month or period of their expenditure by means of an increased burden, or whether they should be held over in a "suspense account" and gradually filtered into the distributed burden over a longer period.

As long as we are content to consider building repairs as connected in some mysterious way with the productive function, such questions will always present many opportunities for argument. If there is any relation between such expenditure and direct production, and if it is capable of being intelligibly expressed by a percentage, then such problems have every claim on our attention. But no such relation exists, because the expenditure on building repairs and the expenditure on direct production belong (as already outlined in the first chapter) to two entirely different functions of the manufacturer—viz., his function as property owner, and his function as producer.

It is at this point that the principles of planning out, of estimating in advance, even of "averaging," come into full play, yet in a totally different sense from their exercise upon the mingled phenomena of the works, where every expenditure is classed as "productive" or "unproductive" and it is sought to express the latter as a percentage of the former. In the method of organization by production factors it is sought *to isolate as many as possible of the special functions exercised by the manufacturer, to determine*

their steady and regular rent-value, by foreseeing their fluctuations, and to charge these rents as regular production factors of perfectly determinable value. It follows, therefore, that on this method a large number of expenses commonly regarded as closely and individually bearing on production are entirely removed from such connection and transferred to other groupings whence they influence the cost of production in a much more regular, separate, and distinct way.

It may be asked how this arrangement is justified and how it squares with the principle laid down at the beginning of this chapter, that "costing is a registration of production events that have actually happened, and it is never anything else." The answer is that the production factor method isolates direct production costs from the confusing influence of a number of other expenditures, and enables the true facts of production to be much more clearly realized than before. Production cost is registered precisely as the events that determine it happened, but the indirect services which go to make production possible, but are not in themselves part of production, are reduced to common values just as the rents of a row of houses

are the reduction to a common value of a variety of heterogeneous expenditures by the house-owner. The accuracy of these common values, which thus become production factors, depends, it is true, on prevoyance, valuation, and planning; but that is not to say that these values or factors are in the least arbitrary or of the nature of guesswork. They are in the nature of hiring or payment for definite services, many of which might even be rendered by other persons or contractors instead of by the manufacturer to himself.

PRODUCTION FACTORS AND STAFF ORGANIZATION.

In the illuminative series of articles already referred to above, Mr. Harrington Emerson has recently demonstrated the difference between "Staff" and "Line" organization, and has shown how important it is that the latter should be supplemented by the former. If staff organization is, as yet, scarcely beginning to be adopted, notwithstanding its very obvious advantages, it is perhaps because up to the present the forms of organization have been such that the necessity for it remained unrealized. From the point of view of those who (to use an example already familiar) have been in the

habit of regarding building repairs as incident on the cost of manufacturing screws, the idea of staff organization is necessarily difficult of realization. But if, long ago in the history of manufacture, "Organization by Production Factors" had been the universal form, then, I venture to think, staff organization would have suggested itself as the natural complement of the existence of such factors.

The moment we cease to mingle and diffuse expenses that have nothing in common, the moment we isolate, on the contrary, all expenditures capable of isolation, and bring clearly into view their factorial nature—then it becomes obvious that the next step is to seek to reduce such factors by expert supervision constantly alert for opportunities.

While, for example, we look at the cost of power as a number of "analyzed" items, such as coal, water-rate, ash removal, drivers' and stokers' wages, etc., it will probably be a long time before it dawns upon us that all this expenditure can be reduced to a horsepower-hour rate, and that such a factor, once known, may turn out to be a standing reproach. The burning of 200 tons of coal per week may mean anything or nothing, but the

cost of a horse-power hour can be compared at once with standard data, and will call either for self-congratulation or loudly and imperatively for the services of an expert. In any case, once a factor is known, the temptation to reduce it is constantly present, and staff organization is obviously the natural way of securing that it shall be done.

As soon as we recognize that *all* the operations that go on in a large works are not productive, nor even *directly* connected with production, but that some of them represent separate and distinct functions exercised for convenience by the manufacturer, so soon shall we realize that each of these separate functions requires expert guidance and is the proper subject of staff activity, in Mr. Emerson's sense.

It may even be claimed that production factors give a wider economic value to staff organization, inasmuch as they enable standards to be set up not only as between today and yesterday in the same works, but as between different works in different places. There can be little doubt that the introduction of production factors and the publication of figures based on them would reveal amazing inefficiencies that under present condi-

tions are unsuspected and unknown because no means of comparison exists. At the present time all such inefficiencies are covered up and hidden in the general term "Expense Burden" or "Establishment Charges," which does not define anything capable of being compared as between different works. Labor costs and rates of wages can be compared, but when we come to speak of burden or charges, no one knows what the term may or may not include.

To say that burden amounts to 100 per cent of wages or 6 pence per man-hour in one works, and 125 per cent or 8 pence per man-hour in another, conveys no meaning as far as *comparative* values are concerned, because under the existing want of standardized practice no one can guess what such statements really mean. The only use, therefore, that can be made of systems of connecting burden with costs, at the present time, is to compare different periods of operation of the same plant or works. Reduction and standardization of expenses will go hand-in-hand when once the purely productive functions are isolated from the others, and these latter made the subject of careful and expert study.

THE IDENTIFICATION OF PRODUCTION FACTORS.

Generally speaking, the method herein advocated consists in isolating each function of the manufacturer not directly productive, and reducing all to unit-values, based not upon the accidental circumstances of the organization, but on an absolute or standardized basis, so that comparison will be possible between different undertakings to a much greater extent and embracing a much larger share of the total activity than at present. For the purposes of practical distribution these unit values will become components of machine rates (with an overflow into a supplementary rate), as arranged under the A. Hamilton Church system of expense-burden distribution already published,* but apart from this, they will have separate value and significance.

The desirability of reducing production factors to separate standardized unit-values was suggested by the curious fact that the same machine working in two different shops was found to have a different machine rate in each shop. This was due to the fact that

*The Proper Distribution of Expense Burden. THE ENGINEERING MAGAZINE.

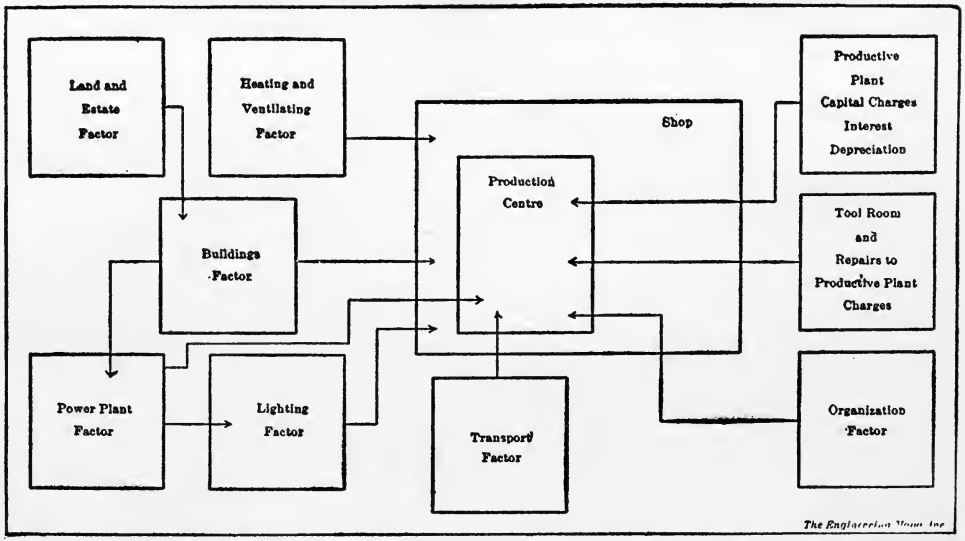

FIG. 1. DIAGRAM SHOWING THE PRINCIPLE OF ORGANIZATION BY PRODUCTION FACTORS.

It will be seen that some of these are incident on floor space and others directly on production centres, which may be a machine or bench, or a plain floor area in an erecting shop or foundry. Those incident on floor space are reduced to a charge per square foot and enter in that form into the production-centre rate (machine rate). It will be noticed that each of these factors represents a special kind of "service" rendered to production, reduced in each case to a unit-value. The indefinite nature of a large number of "indirect charges" is thus replaced by a limited number of definite "rent charges," called herein "production factors."

several items of indirect expense were higher, the building being old and requiring much expenditure, while the power costs were found to be unusually high. The cost of manufacture in one of these shops was actually greater than in the other, a discovery that led to useful reforms. But the necessity for fixing attention on production factors first and foremost was also strongly demonstrated. In the remainder of this book, therefore, the question of how the production factors affect cost through the machine rates will not be much dwelt upon, the information previously published on this subject being practically unaffected by the results of the present inquiry, which is concerned with isolation and collection rather than the distribution of burden factors.

The diagram (Figure 1) shows the general principle involved. Every expense, whether in the nature of standing charges such as interest, depreciation and insurance, or current expenditure such as repairs, renewals and maintenance, is charged directly to the production factor with which it is concerned. Such expenses, therefore, are not mingled with each other, or with the actual manufacturing costs. Being expenditure on separ-

ate functions, they are kept separate, treated in separate books of account, and considered, in fact, as a different class of operations—which they undoubtedly are.

This method sweeps away the greater part of the elaborate classifications found necessary when indirect expenses are dealt with by analysis and percentage. It substitutes a few clearly marked and easily understood lines of activity for a number of fine-spun ones. No source of information but the job order being recognized for the compilation of accounts, it is a comparatively simple matter to charge each job to one of the few accounts required.

After these broader groups of activity are dealt with, there will obviously remain minor charges which are not of sufficient importance to be made into separate factors, or of which the character is difficult to distinguish from actual production. Such charges are treated as a "supplementary rate" which also absorbs unallocated factors due to idle time of production centres. The rise or fall of this rate becomes a measure of shop efficiency.

In commencing to establish a works or factory the first consideration that presents

itself is the site. No uniformity of practice with regard to sites is likely to be attained. We may commence by purchasing a site or by renting one, or we may purchase a portion and rent a portion. But evidently the land-factor, that is, the annual expenditure due to the necessity for holding ground, antedates all other factors. The complexities found in practice tending to make such land factor, and all subsequent factors, difficult of determination, will be dealt with in detail in subsequent chapters—it will suffice now to give a general idea of what the more easily recognized factors are.

Having secured the land, the erections and buildings necessary to the business claim attention. These may exist already or may require to be designed and built. Those already erected may require extensive alterations or repairs. We may rent part of the buildings and erect some additions. Those rented may be taken on a repairing lease of greater or less stringency. But however acquired, buildings have to be maintained, and in some countries, as in Great Britain, statutory cleansings and whitewashings have to be carried out periodically. All these items, and others like them, form a considerable

group of expenditure, entirely worthy of complete isolation, for they represent a function anterior to and separate from the actual productive function. The total expenditure on such function is capable of being reduced to absolute standard data, forming a buildings factor.

In almost every kind of manufacturing business the question of power is an important one. The cost of boilers, engines, cooling towers, and other auxiliary appliances, obviously comes into the power factor. So also does the cost of land which the power house and other apparatus occupies, the cost of buildings, factory chimnies and other erections, cost of coal, wages, water, ash-removal, and similar items—all these contribute their portion to the ascertainment of a power factor, just as though the power instead of being generated on the works were rented from a supply company.

The lighting and heating services are the subject of similar treatment.

In many cases the services of craneage, haulage, conveying, and similar work are of sufficient importance to form a transport factor.

Production-centre factors are those pecu-

liar to each production centre (which may be a large and heavy machine tool, a pattern-maker's bench, or even an empty area of floor in an erecting shop or foundry) and consist of interest and depreciation on the capital value, and various sub-factors representing tool-department services, and the maintenance and repair of the plant, if any.

An organization factor isolates the wages of cost clerks, timekeepers, and other employees solely or partly occupied on organization costs, together with the cost of books, forms, cards, time-clocks and special appliances. This factor, if worked out for a number of different establishments working under different systems, might be expected to reveal remarkable differences in efficiency.

In the next chapter each of these separate groups will be considered in detail, the various items entering into it will be enumerated, and the method of reducing the expenditure on it to a standard or unit-value will be explained.

Chapter III

ELEMENTS OF THE LAND FACTOR

PROVISION of a site on which buildings may be erected is of course antecedent to all other steps in commencing to manufacture. Whether unoccupied land is specially acquired, or a factory is already erected, the site value of the land and certain outgoings and expenditure incident to it remain separate items, and are reducible to unit value. It will be admitted, after brief consideration, that the unit-value of sites may vary within wide limits. In large cities especially, the cost of land and the outgoing expenditure on what may be a cramped and unsatisfactory site frequently amounts to a noticeable burden on manufacture. The high assessments and heavy incidence of taxation on such city sites is giving rise (particularly in Great Britain) to a marked tendency to remove large works to country districts where land can be acquired at something near agricultural value. This tendency develops in spite of the disinclination of skilled labor to

live away from the pleasures and excitements of large towns.

Low unit-value is, however, not the most important consideration in the selection of manufacturing sites. Transport facilities take first place. Much depends also on the character of the labor employed. Some classes of business, requiring the proximity of large reserves of unskilled labor to be drawn on at short notice, cannot be carried on away from crowded centres of population. The neighborhood of raw materials is also in some cases a factor in determining the choice of sites. But an ordinary engineering works has a wider latitude of choice than many others, and, given good transport facilities, its location depends rather on the scale and extent of the proposed undertaking than on the neighborhood of labor or materials. The scale of the undertaking, however, has an important bearing on the question.

A comparatively small factory must of necessity locate itself in the neighborhood of an existing town where housing and marketing accommodation for its employees can be obtained. A concern established, or about to be established, on a very large scale, with ample capital, is more independently placed

as regards its choice of a site, because it can, and frequently does, not only provide its own manufacturing premises, but undertake, also the function of a speculative landowner, and erect model villages, with housing and marketing accommodation, and all the adjuncts necessary to the social life of a community. Many of these model settlements have attracted much public attention and have been described in detail in THE ENGINEERING MAGAZINE,* but we need not consider them in this inquiry further than to remark that they have nothing to do with and should be kept entirely separate and distinct from the manufacturing enterprize proper. This principle applies whether half a dozen cottages are in question or a complete community. Distinct books should be kept for even the smallest development of this kind, and the results dealt with in the manner of any other profitable or unprofitable investment in the periodical balance-sheets. In cases where the feature is an expensive one, it is highly desirable that estate development should be handled by a separately organized corporation.

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*See especially an article by C. B. Going, April, 1901.

The first distinction to be observed, therefore, in commencing the determination of production factors, is between land used for *bona fide* manufacturing purposes, and all other uses. In the latter class will naturally be included land purchased in view of future developments, but not yet in occupation for manufacturing purposes. The acquisition of such land is in the nature of a prudent investment, even though not immediately a productive one, and the capital expenditure and annual outgoings on it should be separately scheduled and enter only into the balance-sheet and final accounts, not mixed up either with manufacturing or trading matters. It may happen in some cases that land so held in reserve retains its agricultural value, for grazing, market-gardening, or other purposes. In such case any revenue arising out of its letting will be set against the outgoings or treated as revenue arising out of the investment. *Only when such land is actually taken over for the purposes of manufacture does it enter into production factors.*

Though the land production factor contains fewer elements than any other, being made up of interest on capital, and outgoings in

the shape of ground rents, chief rents, mortgage interest, amortization of leases, rates and taxes—not all of which are necessarily present at one time—it presents certain complications in the settlement of these items which must be discussed in some detail. Most of these complications arise from the different tenures by which land can be acquired and held.

The simplest case may be taken first. In a newly acquired freehold estate, free from mortgage, all of which is devoted to manufacturing purposes, the items which enter into the land factor are (1) interest on capital, (2) outgoings in the shape of rates or taxes levied upon the site value. Items which bulk considerably in the case of other property do not enter into the consideration of land values. Land, for example, is not subject to depreciation or obsolescence, it does not require expenditure for maintenance or repair, and entails no particular supervision. Only interest and a very limited class of outgoings are thus involved.

The next least complicated case is where the land is taken under a tenure known by different names in different localities, but essentially consisting of a capital payment

for use of the land in perpetuity, but subject to a permanent rent of fixed amount. Where land is held in this way, (1) interest on capital, (2) rent, (3) outgoings form the items reducible to unit value.

In large towns, ordinary leasehold tenure, on which a capital payment is made for the use of the land *for a term of years* subject to a fixed annual payment or "ground rent" is not unusual. This arrangement introduces an altogether new feature into the determination of production factors. We have here (1) interest on capital, (2) ground rent, (3) amortization, (4) outgoings, as the items to be reckoned with. Amortization is the provision necessary to meeting the wasting character of the property, for as the term of the lease is a limited one (frequently 99 years) and as at the end of that time the land reverts to the original owner, it will be obvious that a fund must be accumulated to replace the capital outlay at the end of the lease. This process is in fact exactly equivalent to depreciation on a machine or building. Though the land itself does not decay, the leaseholder's right to the use of it diminishes in value year by year, as the lease approaches its termination.

Under any of these tenures a further complication may be introduced by the existence of a mortgage, or loan secured on the land. Frequently this is brought into existence, where the purchaser's capital is limited, to enable the acquisition of the land to be completed. In other cases it may be brought about at a later date as a means of raising money required for some extra demand in the business. This latter case obviously is a matter of finance, not production.

The problem of the acquisition of additional land under exceptional conditions must also be mentioned. In the case of city works that have developed by a gradual process of accretion it sometimes happens that additional space is very difficult to acquire and that considerable sacrifices have to be made to secure it. It may become necessary to acquire an adjoining site covered with buildings, and pull them down for the purpose of clearing the ground and making it suitable for manufacturing purposes. An expensive proceeding of this nature will naturally make the unit-value of that particular area a very high one, and the question of how this increased value is to be dealt with is a very important one. This is treated in detail later on.

DETERMINATION OF THE LAND FACTOR.

We may now turn our attention to the treatment of the land factor and the method of reducing its items to unit-value.

It may not be out of place to consider, first of all, what is the precise object we have in view. In ordinary accounting methods all the different expenditures arising out of the holding of land are included in a "burden rate" or "establishment charge" and their individuality is lost to sight. By keeping them separate and reducing them to unit-value it is obvious that *we are enabled to obtain a clearer picture of the bearing of site value on production,* and the exact object and use of doing this must be clearly grasped if we are to construct our production factors intelligently. It must be remembered, however, that the land factor, although exactly the same in principle as other factors, is the least significant, because it is made up of fewer elements, and is in itself but one of the smaller items of indirect expense.

The object and use of expressing this, and a number of other expenses, as production factors is three-fold. First we gain a clearer idea of the proportion which each such ex-

pense bears to other expenses and to total cost; second, we are able to observe changes and fluctuations in each such factor separately, and see the effect of new arrangements or new policies and their absolute bearing on the cost of production; third, standardization is effected and the unit-values of one department can be compared with those of another department, and those of a works in one locality with a works in another locality. In collecting and arranging data regarding land we must seek to express in the factor the permanent and significant facts outstanding from a careful survey of the whole situation.

In the case of a new works erected on a site purchased for the purpose, whatever may be the items that go to make up the factor, it is obvious that they will bear uniformly over the whole area. On whatever tenure it is acquired and whatever the outgoings, no one portion of the ground can be considered as bearing a heavier incidence than any other portion, it being always remembered that unoccupied land does not enter into the production factor, although, of course, bearing its own proportion of the total expenditure. But let us now consider the case of a factory that has made extensions at different times, some

of which are more costly than others. How are these additional areas to be dealt with as they come into use? Are they to modify the unit-values already obtaining in the older portion of the works, or are they to bear their own burden, and represent by a higher factor the expensive conditions in which they have been brought into use?

The question is a difficult one and cannot be answered off-hand. We must consider it at some length, as the same principle is involved, and will come up again, with regard to other factors besides land. At the first sight, and if we regard the works as a single unit, it seems absurd not to consider an expensive extension as raising the land factor as a whole. Otherwise, supposing that the same kind of operation were being carried on in both the new part and the old, two different manufacturing costs would result. Though this would be a perfectly true result, and *would represent what was actually taking place,* it would have no practical value in most cases. On the other hand there are circumstances in which it would be both just and wise to allow the higher factors of an extension to represent the actual facts of production. This is so whenever the exten-

sion is used for a different class of operation from the remainder of the works. Suppose for example that a firm decides to do its own castings, and for that purpose buys an adjacent site at a much higher price than had been expended on the rest of the land. Very little argument is necessary to demonstrate that the higher factors due to the extension should be confined to that extension, and not permitted to become a means of fictitiously raising the cost of production in departments with which it has nothing to do. Generally speaking, therefore, the principle to be adopted would appear to be that where different conditions give rise to different factors, and there is no pressing, distinct, and practical advantage in consolidating them with the remainder of the works, they should be treated separately. We may put it in even stronger shape and say that *unless some anomalous and distinctly impracticable result would follow from their being preserved incident on the site to which they belong, they must be so preserved.*

An actual example of the working out of land factors will now be given. The plan (Figure 2) represents a works of which the original portion A was purchased outright.

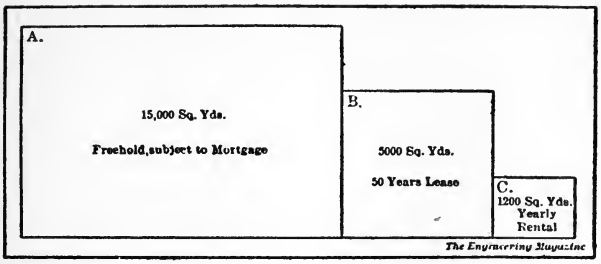

FIG. 2. DIAGRAM OF FACTORY LANDS TO BE REDUCED TO UNIT VALUES.

An extension being required, the portion marked B was obtained on a fifty-years lease at a certain ground rent. A third addition being necessary, the piece of ground C was rented—it being found impossible to purchase or lease it—and only light iron buildings of one story being required for the purpose for which it was acquired. We may also assume that part of the purchase price of the freehold portion A was raised by giving a mortgage of $10,000 on it. We assume also that there is no essential difference between the operations carried on in A and B, but that C forms a separate department, which on the principle laid down above is properly liable to bear its own burdens.

The first step will be to ascertain the unit-value of each separate area, afterwards com-

bining the incidence on portions A and B and treating them as a single area.

Elements of Land Factor for Portion A.—The only complication in this portion is in respect of the mortgage. Two-thirds of the purchase price of the site is assumed to have been raised by this means at 6 per cent. As we assume the rate of interest on the firm's own capital sunk in the investment to be correctly chargeable at 5 per cent, there is a loss of efficiency on the transaction. The question therefore arises as to what is the proper way of dealing with this margin of inefficiency, due it must be assumed to the concern being short of capital, and therefore unable to purchase without having recourse to a mortgage at high interest. In the figures given as an example the difference is trifling, but the *principle* must be determined so as to apply to all cases. We must decide whether the extra expense is properly chargeable to the land factor, or whether it should be considered as a financial matter, pure and simple, and transferred to the profit and loss account. In other words—are we to consider the annual charges on the land at 5 per cent on the purchase price, or as 6 per cent on

two-thirds and 5 per cent on the one-third actually paid for out of capital account?

To solve the problem we must distinguish between the actual and permanent and the accidental circumstances as they affect production. It will be perfectly obvious that the mortgage is a purely accidental handicap, removable at any time, and having no real relation to cost of production. It stands on a totally different footing from the acquisition of an additional site at a high *price,* because the latter is a permanent condition which cannot be remedied. No amount of argument will serve to reduce the incidence of expenditure actually incident on a particular area, but in this case there is a good case for considering that the extra charges involved are not really incident on any particular area. The raising of capital in a particular way has no real connection with the purpose for which that capital is used. Let us consider, for instance, the position of the concern at the commencement of its operations. It had, we may assume, $125,000, of which $120,000 was required for equipment and working capital, leaving only $5,000 available for purchase of land. This seems to connect the shortage definitely with the

cost of land, but another way of looking at the facts will dissipate that view. What really was the case was that the concern had prospective liabilities or use for capital up to a total of $135,000, of which sum it had only $125,000 in hand. It will be seen therefore that it really mortgaged the land to secure an extension of its capital. It cannot rightly be insisted on that the additional amount so raised had anything to do with the land, as land—in fact, but for convenience, it is quite possible that might have been paid for in full, and the additional capital required obtained by hypothecating some other portion of the assets of the concern.

We may adopt the principle, therefore, that financial arrangements should be carefully distinguished from expenditure which is indissolubly bound up with particular operations. The essential and permanent feature in this case is the acquisition of the land at a certain price. The mortgage must be considered in the light of a subsequent financial deal that has nothing to do with the purposes for which the land was purchased, and as not affecting its annual cost in the slightest degree for any manufacturing purpose.

The elimination of the mortgage from

among the items incident on area A leaves us with only two elements of annual cost, namely, interest at 5 per cent on the capital outlay of $15,000, and rates and taxes payable on the site value, which we may assume to be $50. Adding these two items together we have a total annual expenditure of $800 for the area A.

Elements of Land Factor for Portion B.—The tenure of portion B is not freehold, but leasehold. A payment of $2,500 was made for a fifty-years' lease, subject to an annual ground rent of $200. In this case we have to take into account not only the interest on the capital outlay of $2,500, and the ground rent of $200, but we must also provide for the fact that one-fiftieth of the capital disappears each year. That this is so will be manifest from the consideration that at the beginning of the lease it was worth $2,500, while at the end of the fiftieth year it will be worth nothing at all, the leaseholder's rights to the use of the land having expired, and a fresh payment being necessary if a continuance of occupation is desired. In practice, however, the items of interest and amortization are not taken separately but are

consolidated by means of an amortization table which calculates the two items together, and resolves them into (fifty) annual sums of equal amount. A table of this kind will be found in Messrs. Garcke and Fells' "Factory Accounts." The principle of amortization may briefly be stated to be this: Each year a sum larger than the annual interest is set aside, sufficient to replace (at compound interest) the original capital at the end of the given term.

To arrive at the total annual expenditure for area B, therefore, we take the combined interest and amortization (amounting at 5 per cent to $140), adding to it the ground rent ($200) and the rates and taxes on the site (say $20), making a total annual charge of $360.

Elements of Land Factor for Portion C. —This is the simplest of all, the land being simply rented on annual terms. The items concerned are, therefore, rental $150 and taxes $6, giving a total of $156.

Having thus outlined the process of collecting the items that go to make up the totals on which land factors are based, we pass to the reduction of these figures to unit value,

and to the indication of how the resulting land factor is used. First of all, however, it will be necessary to consolidate the figures for areas A and B, since, as already explained, we can draw no distinction between the manufacturing uses of these two areas.

CONSOLIDATION OF ANNUAL VALUES OF SITES A AND B

Interest at 5 per cent on $15,000, purchase of A	$750
Rates and taxes on site value of A	50
Interest at 5 per cent on $2,500 and amortization of 50-years' purchase price of B	140
Ground rent payable on B	200
Rates and taxes on site value of B	20
	$1,160

We thus arrive at a total annual incidence of $1,160 on the combined areas, amounting to (15,000 + 5,000) = 20,000 square yards. Dividing the annual incidence by this we get: $1,160.00 ÷ 20,000, or 5.8 cents per square yard per annum.

Treating area C in the same manner, we arrive at a unit-value of $360.00 ÷ 1,200, or 30 cents per square yard per annum.

It need hardly be mentioned that these unit-values, compared with those of sites in the midst of large cities, are very low. Nevertheless, without comparing them with other

figures, the above examples will be sufficient to illustrate some of the advantages to be gained by habitually thinking of the indirect factors of production in terms of unit-value. A clear recognition of the fact that the unit-value of our land is in the neighborhood of 6 cents per annum for every square yard assists to fix in our minds the relative bearing of land value on production. Asked off-hand, very few manufacturers could tell with any approach to accuracy what was the relative bearing on production of land values in cities and those in country places. In an interesting article on Works Design as a Factor in Manufacturing Economy, contributed to THE ENGINEERING MAGAZINE* by Mr. Henry Hess, the remark is made that "a site in the city itself will generally be too costly for all but light manufacturing." That, probably, in the existing stage of information, is all that can be said on the subject, because attention is never focussed upon site value as a distinct and separate factor of production under present methods of organization and accounting. In the place of definite unit-values only general impressions are current. This applies, of course, not merely

*July, 1904.

to the land factor but to many other factors of production equally capable of being regarded separately, and of which the following chapters will treat.

Mention was made, above, of a suppositious case in which a plot of land covered with cottages or other buildings was acquired, with a view of demolishing the buildings, clearing the site, and using the cleared land for manufacturing purposes. What is the proper way of regarding the expenditure of demolition?

For production-factor purposes this expenditure must be regarded as adding to the cost of the land. As a matter of valuation this may not be the case, but obviously enough the cost of the demolition must be recovered from the work done on the site, the extra expenditure having been incurred as a preliminary to manufacture. If we look at the matter from another standpoint the justice of this plan will be clear. Instead of purchasing the land and doing its own demolition the firm might have rented the land on condition that it was cleared. In such case the rent charged by the owner would necessarily be based not only on the site-value but also on the cost of the demolition. For it

is evident from the circumstances of the case that if the demand for that particular piece of land is so urgent that it will pay to clear it, then the ultimate value of the site is a monopoly value, as is not infrequently the case in city sites.

Under such circumstances the cost of preparing the land for manufacturing uses must be regarded as adding to its price. In this as in other cases the resulting unit-value will exhibit in its true light the bearing of the transaction on production.

It would probably be considered advisable in a case of this kind to write down the value of the site in subsequent years. That is to say, that a portion of the excessive cost would be transferred to profit and loss account. Such a transfer would naturally have the effect of reducing the unit-value, which would have to be recast accordingly, as will be understood by all accountants.

In the case of the two areas worked out above, it will be noticed that a difference of 600 per cent exists between the combined areas A-B and the area C. It is true that on these particular figures the higher value is still not a serious handicap on production. This kind of fact is, of course, one of those

that it is the object of production factors to bring into prominence, and when the whole series of such factors is built up, variations in the efficiency of production can immediately be traced to their causes—or, rather, they will be visible without tracing.

The land factor, however, does not directly form a component of machine rates. It is, in fact, an indirect factor, inasmuch as it has in nearly all circumstances to become merged in another factor, viz., buildings. This does not affect its utility, but assists in locating inefficiency—the advantages of a low land factor may be neutralized by improper types of buildings, and this, if it occur, will be relentlessly shown up. Another peculiarity of the land factor is that it is an "invariable" factor. That is to say, it does not vary with intensity of output at different periods. We shall see later that all factors fall into two groups—variable and invariable, the one group having some relation with the volume of work, the other none at all. This is a distinction that has hitherto escaped emphasis, and no attempt has been made to examine into its actual influence on costs.

We must leave the further consideration of the land factor at this stage, having ex-

plained how, under a variety of conditions, the unit-value is arrived at. In the next chapter buildings will be dealt with, and the actual employment of these unit-values illustrated.

Chapter IV

BUILDINGS, HEATING AND VENTILATION, STORES, AND ORGANIZATION

AFTER land, buildings come next in sequence. Few operations are carried on in the open air, and all but the roughest kind of storage is usually sheltered. Normally, therefore, the land factor is merged in a buildings factor, and does not itself pass into the machine rate of a production centre.

The elements of a buildings factor comprise *all charges for the maintenance of the building as a factory,* including not only rent charges or their equivalent in interest and depreciation on capital expenditure, but also the expenses of repairing, maintaining, painting, whitewashing and cleaning. These charges which are in the nature of rent present the most complication, inasmuch as their bases vary greatly according to circumstances, depending on whether the building is leased or owned.

The former is the simplest case. Where a factory is held on simple lease, the annual rent paid represents the whole of the rent charge. In such cases the land factor does not appear, for it is implied in the rent paid to the landlord, which includes it. Where a dilapidation clause is in force that compels the tenant to hand over the building in original condition at the end of his tenancy, provision for this must be made by means of a sinking fund or at least a reserve account. Otherwise the chief elements of a buildings factor are the following:—

Landlord's rent.
Amortization of lease (if any).
Rates and taxes.
} A land factor is implied in these, but is not of course distinguishable.

Insurance on building.
Annual cost of repairs and maintenance.
Annual cost of painting and whitewashing.
Annual cost of cleaning.

In cases where the land has been purchased (and its value reduced to a land factor) and buildings have been erected by the manufacturer, the elements are naturally different. Instead of a simple rent charge, we have to take into account the land factor, as representing rental of land and interest and de-

preciation on the building that has been erected. The principal elements will then be:—

Land factor. Interest on capital value of building. Depreciation of building.	These three elements are equivalent to landlord's rent, and amortization, (if any).
Rates and taxes. Insurance on building. Annual cost of repairs. Annual cost of painting, etc. Annual cost of cleaning.	As before.

These items will, of course, be assessed separately for each building. In this case no averaging (as between buildings) can be permitted. Every separate building will have peculiarities, and only by recognizing these can a true buildings factor be obtained. Thus, the power house (with which will be included a separate assessment for the factory chimney stack), the shops, foundry, pattern stores, offices, and warehouse will all be found to have different buildings factors representing the true annual charge for accommodation of the operations carried on in them. Some buildings will be of one story and some of several stories. In a long established factory some will be old, and carry a heavy annual charge for repairs and main-

tenance, and some will be new, with a small charge. The separate annual values brought out by the factor method will force the question of buildings-efficiency prominently into notice. In one respect buildings and all other factors of production differ from land, in the case of which, it will be remembered, the principle of averaging was to a certain extent admitted. The diverse annual charges on adjacent sites were aggregated and averaged in certain circumstances, and this was allowable *because the incidence of land charges cannot be reduced by any improvement or change of policy.* There is nothing individual about the different portions of a level site, and nothing that can be modified or reorganized. But in every other case we are dealing with artificial structures or arrangements capable of alteration and improvement in efficiency. It is the object of the production-factor method to keep the charges on each such element of production separate and localized so that its true bearing on production is exhibited and its efficiency made manifest.

It will be noticed that three of the items of the buildings factor are estimated, or rather forecast. Those for painting, whitewash-

ing, and cleaning will present no difficulty, but the annual charge for repairs requires careful determination. This should be an annual average charge based not upon the accidental circumstances of any one year, but on what is spent or likely to be spent one year with another. The object of this is to give a steady figure, representing real annual cost, and not a violently fluctuating one that affects costs in a meaningless way. Any discrepancy between the amount *actually* expended in any one year and the amount *forecast* in the buildings factor will be dealt with in a way that will be discussed when the general bearing of the method on costs is discussed.

It will now be obvious that we are in a position to ascertain with close accuracy what is the actual out-of-pocket cost per annum of each separate building forming part of the undertaking. Such annual cost will be that of each building as a "going concern," maintained in a condition ready for use for any purpose required. In this way we have already reduced considerable groups of expenditure to perfectly definite issues, and by dividing the total *available* floor space of each building into the annual cost of such

building we arrive at a rent per square yard that necessarily represents the cost due to land and buildings in every operation carried out on any of those square yards.

In determining *available* floor space, only such areas are reckoned as can be used productively. Thus, galleries, landings, passages and stairways are omitted from the divisor, which consists solely of what may be termed the net area. Whether such net available area is actually occupied by production centres does not affect the matter. We have to proceed as if the buildings were empty and assess their net *capacity* for use, not their actual use. The actual use may speedily be seen to be wasteful and inefficient, once all the factors of each production centre are determined.

In some cases reduction to annual cost per square yard is not required for the purpose of costing, but it should always be done as establishing a unit value for comparison with the similar buildings of other undertakings. This will apply to the power house in most cases, and to the buildings used for stores and offices. The reason will be seen when we come to deal with the determination of production factors in those departments.

THE POWER FACTOR.

Having now established the cost factor of buildings ready for occupation on a basis which may be used for machine-rate assessment, the reduction of the power service to an equally assessable basis is the next most important step. The elements of the power service are many and include every expenditure relating to the generation and distribution of power and its delivery at the point of application. The total of such expenditure when collected is reduced ultimately to a factor of production-centre machine rates on this basis.

The simplest conditions governing the power factor are those obtaining when a city or power-company's current is used direct and the whole installation, motors included, is hired. The charge per kilowatt-hour, or per horse-power hour, becomes then the power factor without any further trouble, and so enters into the machine rate.

This case is interesting as showing all charges merged of necessity into *a simple rent for a particular service to production*—viz., power supply—the whole object of the production-factor method being to reduce the

cost of a number of other heterogeneous services to simple rents in the same way. That the manufacturer undertakes to make his own current or supply himself with his own power is no good reason for not ascertaining what it costs him in the form of a definite rate, just as if he had purchased it from outside. Indeed it is the very best reason for reducing his power expenditure to such a rate.

The next simplest condition is where current is purchased, but all the transmission and distribution appliances are the property of and are maintained by the manufacturer. In such cases the elements are as follows:—

1. Interest
2. Depreciation } of { Motors, switchboards, cables, meters, switches, shafting, pulleys, belting, etc.
3. Maintenance
4. Annual cost of current.

N. B. The cost of maintenance includes repairs, attendance and all similar expenses.

The annual charge for each of these elements having been determined, the total cost divided by the number of horse power actually consumed will give, as before, the cost per horse power as delivered and used at the production centres.

Where the current is not used as received, but is taken at a high voltage and transformed, or taken alternating and converted to direct, the annual charges for the transforming station must be added to the above. They will consist of:—

5. Buildings factor of station.
6. Interest and depreciation on transforming plant.

In the majority of factories, however, the ramifications of the power service are much more extensive than this. One, two or more centres of power generation may be employed. A central boiler plant may serve to feed scattered steam engines. The transmission system may be partly mechanical and partly electrical. It may include pneumatic and hydraulic installations for special purposes. Water power may be used at one period of the year, and replaced or supplemented by steam power at another. There is, in fact, scarcely any limit to the variety and complexity which the power service may present. It will be obvious that it would take a considerable volume to deal with the proper treatment of all possible combinations. Fortunately this detailed treatment

is not necessary, for the underlying principles are simple, and the most complex practical arrangement differs only in degree from the case of rented electrical power just given.

Power costs must not be averaged. If there is more than one centre of generation, or if with one such centre there are several kinds of transmission, or even several main directions of supply of one kind of transmission, each of these must be carefully traced down and its power delivery cost worked out separately. Only in this way can the essential advantage of production factors—the localizing and isolating of so-called indirect expenses—be attained.

Briefly summarized, the elements of any kind of power service will be mainly these:—

1. Buildings.
   (a). Where plant is erected without roofs or walls, as cooling towers or softeners, the land factor of area occupied takes the place of a buildings factor.
   (b). Where plant is erected in buildings, as boiler houses, engine houses, pumping house, etc., the buildings factor will be first determined in the usual way.
2. Generating plant.
   Buildings factors and land factors concerned.
   Interest and depreciation on engines, boilers, and on all auxiliary plant.

Fuel, including delivery, storage, stoking and ash removal.
Maintenance and repair including labor.
Cost of water, softening chemicals, etc.
Oil, grease, waste, etc.
Labor and attendance.

3. Transmission plant.
   (a). If electrical,
      Same elements as supply from city mains (above) but including interest, depreciation and maintenance of dynamos.
   (b). If mechanical,
      Interest depreciation and maintenance of clutch gears, shafting, pulleys, belts, etc.

N. B. Maintenance includes lubrication, and materials therefor.

The best guide to the proper procedure for determining power factors will be the considerations developed in the opening chapters and above referred to, viz:—that *the function of the manufacturer as a supplier of power has no relation to his manufacturing function other than in respect to the cost of the power so supplied to himself.* The object sought is, therefore, the isolation of all expenditure arising out of this special supplying function. Once this principle—and it is simple enough—is thoroughly grasped, the disentanglement of the charges belonging to the most complex and involved system of

power supply will present few difficulties to a person technically competent. The total cost of all kinds being arrived at, its division by the total horse power consumed—the aggregate of consumption by all machines during the working hours of the year—will give a horse-power-year rate that becomes a factor of each machine rate and represents the cost of power on any kind of operation performed by a production centre, from planing an engine baseplate to turning a thousand studs on an automatic machine. The actual way in which the power factor is used in machine rates will be dealt with in the next chapter.

LIGHTING.

Electric lighting being very generally in use in modern works, and being derived from the power plant, this factor is usually intimately connected with power, but to begin with, and to exhibit the principle in a concrete form, the case of a factory using gas taken from the mains and consumed both in small lights and in large regenerative shop lights will be taken.

The settlement of unit-value of light is made on a basis similar to that of the build-

ings factor, viz., on a capacity-area. Lighting, however, may be both general and individual. The general lighting of the shop may require supplementing by individual lights for particular production centres. The cost of such lights is of course deducted from the general lighting cost, and applied as will be discussed when Machine Rates are considered.

In the case of shops lighted by gas, the factorial elements will be:—

1. Interest and depreciation on the lamps and suspension tackle, and on the mains, valves and pipes.
2. Maintenance of ditto, including attendance and repair.
3. Cost of gas.

These figures are collected separately for each building. Each shop bears its own proper proportion of exceptional features. Thus in the case of an isolated building requiring a long special main, the annual charges on this main would be borne by the shop for whose benefit it was maintained.

Where electricity from the firm's own plant is supplied the problem is varied only in form and details. Cables take the place of pipes, and current of gas. Interest, depre-

ciation and maintenance of the special dynamo should of course be included in the cost of electricity. Whether or not the ordinary factor is used to represent cost of power depends upon circumstances. The primary object of a plant being to provide power for the shops, the use of current for lighting might sometimes be considered in the light of a bye-product of the general power supply. The relatively small call for lighting raises the average load on the engine, but the extra *cost* of such additional output may be in small proportion to the lighting energy supplied. This is a matter for practical determination and estimate in each case. Some interesting hints will be found in an article by Mr. P. R. Moses, "The Electric Equipment of Workshops."* The same writer's article on "Power Equipment for the Small Factory"† may also be consulted.

On whatever system lighting is effected, its separate cost for each building will be fairly simple on these lines. Having arrived at such separate annual cost, division by the capacity-area of each building will give the unit cost per square yard per annum. This

*The Engineering Magazine, September, 1904.
†The Engineering Magazine, March, 1908.

unit cost enters directly into the machine rate as a factor.

HEATING AND VENTILATING.

Heating and ventilating may be considered as opposite sides of the same problem, namely the maintenance of an atmosphere of pure air at uniform temperature in the shops. In as far as ventilation is a matter of building construction it has of course no assessable value for our present purpose. But where special mechanism is involved—blowers, fans, piping and mechanical ventilating appliances —these form a separate and consequently assessable service to production. Heating methods being always artificial necessarily form an assessable service in every case.

It must be remembered that we are dealing here with the general or regulative aspects of both heating and ventilation. Either of these as a process forms part of the direct equipment of production centres and will be dealt with when the consideration of machine rates is entered upon. Examples of these latter applications are tempering and hardening furnaces, and exhausting appliances in connection with emery grinding. They have nothing to do with the present problem.

In the United States, warm-air heating is in much more general use than in Europe. In many British factories slow-combustion stoves conveniently located about the shops supply all the heat necessary. The cost of such heating is represented mainly by cost of fuel and laborers' time in stoking and attendance. Generally speaking British and to some extent Continental preference is for radiated heat, while Americans adopt convected heat.

In either case reduction to unit-value per capacity-area of buildings heated must proceed upon the same lines. In the case of stoves and all similar self-contained heating appliances the problem is too obvious to need discussion. Where steam pipes and local radiators are in use the elements of the heating factor for any building are mainly as follows:—

1. Interest, depreciation and maintenance of pipes and radiators.
2. Value of steam consumed.

Where a special boiler is used to generate steam, its value is added to item 1 and cost of fuel takes the place of item 2. Where convected heat is employed, the problem is

much the same. Fuel applied to the coils of the heater takes the place of cost of steam in item 2. Specially expensive arrangements for any shop, as, for example long lengths of main pipe to isolated shops, will fall on the shops for which the expense is incurred.

The total cost of heating the shop during an average year being ascertained, this amount is divided by the capacity-area of the building. The result will be a unit-value per square yard heated. This involves the assumption that one year will be much like another in its call on the heating apparatus. It must not be forgotten, however, that heat is required over a portion of the year only, while its incidence is spread over the whole year. Unless therefore in the case of an altogether exceptionally long and severe winter the discrepancy between the estimated and the actual expenditure per average day throughout the year would be negligible. Nevertheless the item should be carefully watched to see that any discrepancy is kept within bounds. How this is done will be shown later.

Where ventilating installations comprise piping, fans, and mechanical devices they are dealt with in the same way and on the

same basis as heating, power for driving fans being substituted for cost of steam or fuel.

STORES AND TRANSPORT.

Up to this point we have been dealing with production factors in which reduction to unit-cost on a floor-area or horse-power basis will be a tolerably familiar idea to most manufacturers. We have now to consider a quite different class of expenses that hitherto it has never been attempted to group together naturally, still less to express as a definite and assessable factor of cost. The heading of this section gives the key-note of the procedure, viz., that the expenditure incurred in storing, handling, transporting and delivering raw materials is capable of being separated out from all other expenditure and considered as having its own special incidence on production.

It must be emphasized at the outset that transport implies here, the handling of materials *in course of manufacture* alone. It does not, for instance, include the handling and transporting of coal or the conveying and dumping of ashes and clinker, all of which operations fall within the province of the power factor. Nor has it to do with the

freightage and delivery of the finished product, except into warehouse in the case of a product that is regularly stocked for sale. The word "stores" here means raw and partly finished materials, as distinguished from "stock" which represents finished and saleable goods.

A comparatively brief examination of the question will serve to show that the movement of raw materials (1) in and about the place of storage, (2) from the stores to the shops, (3) from one machine to another, (4) from one department to another, belongs to one and the same class of activity. In all well arranged factories such movements are at a minimum. Where the cost of such movements is high it represents in most cases reducible inefficiency. Most certainly it forms, in accordance with our definition of indirect expense, *a particular class of service* rendered to production. That being the case it is obviously capable of being expressed as a factor of production, high or low according to relative efficiency. Further, whether raw or partly finished materials are kept in stores in charge of a stores keeper, in the shops in charge of a foreman, or in an assembling room in charge of a production clerk, such

storage merely represents the halting places in a general process of movement. The whole process is that of the *circulation of materials,* which necessarily involves both movement and rest—which in fact starts from rest (in the stores) and returns to rest (either in the stores again, as in the case of finished parts), or in the warehouse as saleable stock. Stores and transport are therefore different aspects of one and the same service to production, and we have now to consider what are the elements of expense pertaining to such service, and how they can be reduced to a factor of production-centre machine rates.

A preliminary examination will show the principal elements to be:—

1. MATERIALS IN STORES

Buildings, lighting, and heating factors.
Interest, depreciation, and maintenance of stores fittings.
Wages of stores keepers.
Carriage inwards on materials.
Interest on current balance of stores.

Total annual expense of stores.

2. MATERIALS IN MOVEMENT

Interest, depreciation and maintenance of:—
cranes and hoists, transporters and runways, lifting blocks and tackle
Wages of cranemen and laborers.
Power factor.

Total annual expense of transport.

TOTAL ANNUAL EXPENSE OF STORES-TRANSPORT.

These totals, however interesting, do not bring us any nearer to finding a basis of assessment. The principle being laid down throughout these articles is that the proper place for the transference of the incidence of burden to work *is the point of the tool,* it therefore follows that this basis of assessment will be of a different nature from any we have yet considered.

Looking at the question broadly we shall perceive that this class of expenditure has relation to bulk and weight rather than to value. The storage and handling of a gun-metal casting costs no more than that of one of the commonest and cheapest iron. A partly finished cylinder costs no more to handle than the original rough casting. It is therefore weight and bulk rather than value that must be taken as a guiding principle in our search for a basis of assessment. A little consideration will show that the movements of a large casting have a very close relation to the working of production centres, such as machine-tools. Castings or any kind of materials are not moved about for amusement. Every movement has some relation to work

either just done or about to be done. It will therefore also bear some relation to the nature and importance of the tool. Again, a large overhead traveller is not put in motion in order to supply metal rods to a group of screw machines, neither is the cost of a continuous band conveyer receiving the product of such machines in any way related to the work of heavy planing and milling machines because these latter may happen to be located in the same shop. The solution of a basis for assessment of a stores-transport factor is outlined by these considerations, and is shown to have certain natural lines of development. The principle, not of "analyzing," but of "keeping separate," shows the course to be adopted.

It may be said at once that there is no magic formula, no convenient multiplier or percentage, that will solve such a problem off-hand. One "simple" method will of course suggest itself to those to whom simplicity is an end in itself, viz., the expression of cost and storage as a percentage of the value of stores issued. But not only has it been shown that bulk and weight rather than value are the real bases of connection, but there is also the very important consid-

eration that transport is more or less a continuous or repeated operation, and the ultimate cost of transport for a heavy piece of work depends not only on the initial weight or cost of the casting, but still more on the number of times that it has been necessary to handle it. Further, the large casting rarely passes through the stores at all. It goes direct from the foundry or the works gate to the place where the first operation is to be performed on it. It has also been shown that certain kinds of transport are confined to the products of particular classes of machines. Such an invitingly "simple" method, therefore, takes no account of the very features that it is necessary to emphasize if the resulting factor is to be any guide to realized or unrealized efficiency. It would merely produce a figure of no utility whatever as a guide to such condition of efficiency.

It may also be said at once that the determination of this factor is a troublesome though not necessarily a difficult undertaking. It requires a broad and competent survey of every detail of the movements of stores and materials. It is one of the good points of the production-factor method that it does

press such reviews of different services, not merely on the attention of the accountant, but also on the attention of some technically qualified person. The stores-transport factor can only be determined by first assembling all the elements of that class of expense, and then carefully tracing out their connection with production centres. These elements divide themselves into general and special—the former, represented by the cost of stores keeping and of any mechanism of transport such as a runway that cannot be connected with the products of any particular group of tools, and the latter by the transport facilities that are localized and serve particular groups of production centres.

The allocation of general stores-keeping expense is first made by departments, and the basis of such distribution is a careful estimate of the relative call of each department on it. This will depend on the average volume of transactions, such as the number and weight of articles handled, and the whole circumstances of the business done. A very close approximation to facts can be made if this mapping out of the relative share of each department is done carefully and attentively. It will be obvious that sub-stores, as-

sembling-rooms, and similar items already connected with the work of particular departments will not be thrown into the common charge for stores-keeping and then served out again. Such items will be kept localized from the beginning. Only absolutely common services must be included in the allocation to departments.

Particularized items, as already defined, will be kept separate until the time comes to connect them with machine rates as will be discussed in the next chapter.

The result of this preliminary mapping out of the field of stores-transport will be that each department will have:—(1) a share of the general stores-keeping expense proportional to the bulk of its transactions; (2) a number of particularized stores-keeping and transport charges already seen to be connected with groups or kinds of production centres. With this degree of localization we must leave the question at present. The principle on which these still floating charges are fixed and made factors of machines rates must be left to the next chapter. It may however be mentioned that the same process of careful determination of relative use of these services is employed for fixing the

amount to be borne by different machines. The provision for checking actual and estimated performance must also be left to the same occasion.

THE ORGANIZATION FACTOR.

The last of the important indirect services to production, (with the exception of management and supervision) is that which comprises the working of cost systems, timekeeping, and methods of tracing and regulating the progress of work through the shops, including the routine of orders, and purchasing, but not selling. Such expenditure forms a clearly defined and easily isolated group, although in a few cases care must be taken with regard to the wages and salaries of men with multiple duties. In view of the great development that has taken place of recent years in methods of organization, comparative figures with regard to the costs of organization would possess the greatest interest, and very wide variations of value and efficiency would be revealed if they were made generally available by publication of standardized figures. In the absence of such data or of any basis for comparison, a great deal of wasted expenditure is undetected.

The elements of the organization factor may be summarized as follows:

1. Buildings factor of special offices.
2. Wages of time keepers, cost clerks, and order clerks.
3. Expenditure on forms, books and cards.
4. Percentage of expenses in accounting department representing time given to works costs and purchasing.
5. Wages of watchmen.
6. Interest, depreciation and maintenance of special appliances, furniture, calculating-machines, typewriters, etc.

The annual expenditure on these and similar items being collocated and verified, it remains to decide on a basis of assessment. Such a basis is most usefully and accurately found in a division by the total number of production centres throughout the works. The whole object of organization being to marshal work systematically so that it may undergo operations with the least delay, and to record the cost of such operations correctly, it follows that this class of expenditure has a very definite relation to the activity of production centres. The only question is whether there is any greater call exercised by any particular class of machine than by any other class. A careful survey will

show that this suggestion is untenable. The larger class of machines, for example, make no clearly defined demand for a larger share of organization work than the small. Cost work has a much closer relation to the number of machines than to their size or value. Substantial justice will therefore be done if we regard each production centre as having an equal share of the cost of organization. It will be noticed that this division is also practically equivalent to an equal distribution per head of the productive staff. The division by the number of production centres provides, of course, a figure ready to hand for inclusion as a factor of machine rates.

MANAGEMENT AND SUPERVISION.

In dealing with management and supervision we pass again into a field requiring somewhat careful survey. The elements of the factor are:—

1. Works manager's salary.
2. Wages of foremen.
3. Wages of leading hands not capable of direct charging.
4. Cost of inspection.
5. Buildings factor of special offices.
6. Interest and depreciation and maintenance of furniture, fixtures, etc., used in this department of work.

Following the lines of keeping all expenditures localized as far as possible, we see that the cost of inspection is closely related to the machines of which the products are inspected (inspection by a special official is of course meant, not simple "passing" by a foreman). The supervision of leading hands is similarly localized. The wages of foremen are localized to a less extent, viz., by departments. The expenses of management alone are absolutely general.

Here again, no golden rule for a simple assessment is possible. We must begin by taking the localized expenses, observe how they are related to each production centre that they serve, and divide them up accordingly. In the same manner we deal with the less generalized expenses, in larger groups, until all are exhausted. The absolutely general expenses of management are first allocated to departments by a careful study of the relative demand of such departments on the time and resources of the management. Some departments will be found to take a large percentage, others will obviously take very little, depending upon the complexity of the work carried on. The element of judgment that enters into this factor will make

it none the less accurate if the circumstances are thoroughly gone into.

Having thus dealt with the principal factors of manufacturing production, we shall give attention in the next chapter to a demonstration of the precise means whereby these factors are connected with particular production centres and so become machine-rate factors.

Chapter V

APPORTIONING INDIRECT EXPENSE BY PRODUCTION FACTORS

IN the preceding chapter the general plan of the production-factor method has been, so to speak, roughed out. Two main principles have emerged, viz., the reduction of non-productive work to different classes of "services" rendered to actual production, and the grouping of all indirect expense into these *natural* classes instead of into purely *accountancy* classifications such as the consolidation of all charges for depreciation, for rent, for interest, for repairs, etc., irrespective of the purposes for which these charges were incurred.

The general point of view has been established that indirect expenses are incurred for the most part in connection with the exercise of certain special functions that the manufacturer assumes for his own convenience, but which are quite distinguishable in

their nature from manufacturing proper—the landlord function and the power-supplier function being good examples. The expenditures incurred in performing these functions being readily distinguishable, it follows that they can be expressed as separate factors of production.

Certain of these functions may be called "separable" inasmuch as they are not *necessarily* carried on by the manufacturer himself, and in many cases are not carried on by him—simple rents for premises, or for power supply, being paid to outside persons in return for the services in question. On the other hand, the same principle has been extended to certain other functions, such as "organization" and "supervision," that are always exercised by the manufacturer himself, and never contracted for with outside parties. It has been shown that these latter classes of expense can be treated on the same basis as the separable functions, that they form well-defined and distinct services to production, and that, consequently, they also can be expressed as factors of manufacturing.

It will now be necessary to consider the meeting-place of the production factors (rep-

resenting the cost of the various "services") with the actual and direct processes of production. As has already been indicated, this meeting takes place at the production centres themselves, and the "burden," made up of a number of different items, is discharged on to the work *at the point of the tool.* The latter phrase so well illustrates an important principle that it is advisable to consider more closely the idea that it suggests.

If profit is to be made anywhere in manufacturing it must be made at the point where the tool touches the work. Unless an expenditure subserves, in some way, the efficient operation of the tool on the work, it is wasted expenditure. In as far as it does not subserve it in the most economical manner, it is wasted expenditure. Given any particular kind of work to be done, there will be a maximum number of services and a maximum cost of those services necessary to the correct performance of the work, and anything beyond this is waste. The tool point is therefore the focus to which all expenditure converges, and to the operation of which all activity is subservient. It is obvious therefore that if we can find a means of expressing the value of these services *in terms*

of the time of operation of the tool, we shall be near a very complete understanding and a very strong control of the whole process of manufacture.

The several factors of production, as we have already defined them, may be exhibited in their relation to production centres as follows:

PRODUCTION-CENTRE FACTORS.

	Incident by	
Land-Building Factor	"	--Floor area.
Power Factor	"	--Horse power used.
Lighting Factor	"	--Floor area.
Heating Factor	"	--Floor area.
Stores-Transport Factor	"	--Special determination.
Organization Factor	"	--Simple division.
Supervision Factor	"	--Special determination.

In addition to these services, another group of expenditures exists, arising out of the character of the production centre itself and the necessity for maintaining its functions in efficient activity. First among these are the charges arising from the capital value of the machine, viz., interest and depreciation. Secondly, the amount expended from time to time to keep the machine up to the standard of working efficiency, viz., repairs. Thirdly, an allowance for oil and waste, commonly proportioned according to the size and nature of the machine. Fourth-

ly, a tool charge, representing the value of tools consumed in the ordinary working and the cost of grinding and sharpening them. In certain special cases a fifth charge is recognized, representing the wear and maintenance of jigs and templates, where these are an essential part of operation, as in press tools and stamping machines. These additional factors may be summarized as follows:

INDIVIDUAL FACTORS OF PRODUCTION CENTRES.

Insurance, Interest and Depreciation on Capital Value.
Average cost of maintaining and repairing.
Oil, Waste, and Stores sundries Allowance.
Tool-room charge.
Jig and Template charge (in special cases).

It will be obvious that these are entirely localized factors; that is, they cannot by any stretch of imagination be considered as having any relation to any other production centre or to the work done on any other such centre. The average cost of maintaining and repairing, and the tool-room charge, are in the first instance dependent on determination by judgment; but by the aid of control accounts which will be explained in the next chapter, these and other factors are

prevented from straying very far from substantial accuracy, though in fact careful preliminary determinations will be generally in practical accordance with the facts.

Assuming now that all these factors have been carefully tabulated, and the special determinations necessary have been made by competent authorities, it will be difficult to avoid the conclusion that we have here an actual incidence of indirect expense at the tool point. Had such a method been in use early in the history of manufacturing it is inconceivable that it could have become superseded by any of the existing systems of lumping together all the different items of expense, and then plastering them over work indiscriminately on either a wages-value or an hour-value basis. All such methods would appear to be the substitution of vagueness for definiteness, and it is fairly certain that they would never have been even discussed.

It will, however, be seen at once, by those familiar with these matters, that this exactness of incidence is wholly dependent on a normal working period. If, for instance, in settling our factors we assume a regular working of fifty 54-hour weeks in the year,

equal to 2,700 working hours per annum, it is obvious that if some of the production centres are unemployed for a part of the time, not all the indirect expenses of production incurred in the shop will be distributed. This is true; but before describing the remedy, let us look at what this condition of unemployment really means.

In the first place it means waste. Though it may be unavoidable, and imposed on the shops by force of circumstances, it none the less remains waste. The particular kind of waste involved is waste of manufacturing resources. The fully organized shop represents capacity for manufacturing; its idleness therefore represents wasted capacity for manufacturing. A well recognized feature of indirect expense is that it remains stationary through considerable fluctuations of the volume of work passing through the shops. The production-factor method shows us very clearly why. Under the most urgent pressure of circumstances certain of the factors cannot be reduced at all, and others could only be reduced with great disturbance, and loss of elasticity and of efficiency.

Unemployment of production centres means therefore that a certain portion of

the services maintained for the purpose of assisting production is running to waste. This circumstance, however, *does not affect the value of those services to the production still going on.* They remain as before. The production centres actually working take up no more room, do not consume more or less power, and require the same amount of supervision whether the others are idle or working. It seems obvious, therefore, that though in one sense and looking at the shop as a whole the cost of the whole volume of production is actually higher (and the percentage of indirect expenses to labor on the old averaging methods would rise in proportion to the idleness of machines), yet the cost of the work that is being actually done really consists of two entirely distinct portions, viz., (1) the normal cost, due to the call on services at the tool point, and (2) another portion that simply represents waste. This latter item really represents, in fact, *the incidence of indirect charges on work that was* NOT *done.*

THE SUPPLEMENTARY RATE.

However carefully the incidence of the various services at the tool point may be de-

termined, it is an absolutely necessary element of accurate representation of the facts of production that some provision be made for keeping the cost of wasted time and resources separate from normal costs. The alternative to this is a loss of the advantages which this separate determination of factors gives, and a fall to the level of average or percentage systems. It is even somewhat questionable whether any imperative necessity exists to express this waste as an element of the cost of jobs at all. Strictly speaking it is no part of such cost. If for example only half the machines in a shop are working, half the resources of the shop, roughly speaking, are being wasted. Under any percentage system the incidence of indirect charges on the work actually going through would be, roughly, doubled. On the production-factor plan, the incidence at the tool point, on the work actually going through, would remain unchanged; but the balance of wasted resources would be known as a separate amount and expressed as a *separate* percentage of the normal cost, if desired. Which of the two plans is the most truthful, and which is the most useful? Surely the one that keeps the normal inci-

dence unaltered and expresses the waste separately.

In practical working this is effected by what is termed a "supplementary rate." The relation of such a rate to the normal cost must of necessity be arbitrary, for it is not in itself a cost at all, but merely the *ratio of wasted capacity to utilized capacity.* In all percentage systems this wasted capacity is mixed up and charged along with utilized capacity as an increased total incidence of expenditure. No doubt one of the reasons why the practical mind has looked coldly on all burden-distributing systems is an unconscious perception that they cease to mean anything definite as soon as there is any departure from full time and normal working.

The determination of the supplementary rate is a very simple matter. The total amount that should be transferred to the work by all the machines in a given shop working full time being, of course, known, the difference between this total and the actual amount distributed in any given period, say a month, will represent a total of wasted resources in that shop. Its relation to the work actually done can then be expressed by a simple ratio, and the basis of this ratio is a mat-

ter of no great consequence. A simple and convenient plan is to express it in the form of an hour-charge—that is, so many cents per hour actually worked. Under any circumstances the rate is simply a memorandum of the ratio of waste to production. It is in no sense a cost, since it can afford no information of service either for estimating or for comparison with past or future jobs of the same kind. It merely represents the accidental circumstances of the shop during the period, and to that extent is a barometer of conditions.

It may be asked, why go to the trouble of distributing it? There is in fact no particular advantage in doing so from the costs standpoint. As it only represents *the elimination from normal costs of something that would otherwise conceal them,* any significance that the ratio possesses can be just as well expressed by a single monthly total made known to the responsible parties. Its distribution is in fact a concession to those who like to see every item of expense "distributed" over work, without regard to whether such distribution teaches anything or not. The principle involved will be made clearer by a tabular statement:—

ELEMENTS OF PROCESS COST, WHERE EVERYTHING IS DISTRIBUTED.

Labor, expressed as an hourly wage rate.
Utilized expense, expressed as an hourly rate at the tool point.
Supplementary rate, being idle machine incidence for the period (month) expressed as an hour rate.

It will be obvious that when the costs of all work done in the month are taken, the total expense will have been charged to it in two portions, viz:—

TOTAL SHOP EXPENSE IN A GIVEN PERIOD.

Utilized expense, transferred to work at tool point.
Wasted expense, transferred to work per Supplementary Rate on an hour-value basis, as a separate element of cost.

It must not be overlooked that the ratio of wasted to utilized capacity is, in itself, a most important and significant figure, and if the production-factor method did nothing more than make this ratio known it would give advantages not otherwise to be attained. It is a figure of the utmost interest to the management, but whether anything is gained, *from the costs point of view,* by expressing it as a portion of individual costs is, as stated above, a matter open to argument. If we decide in favor of its distribution over work, it will be for reasons that have relation to

accountancy and financial bookkeeping rather than to the use of costs as costs. The best that can be said for the plan from the costs point of view is that it forces the accidental conditions of the shops into prominence, and so prevents them being overlooked. But in reading such costs, the true meaning of this rate, viz., *waste,* must be kept steadily in mind. With this proviso there is no objection to its inclusion as a separate element of cost.

Generally speaking, there falls into the supplementary rate all expenditure for which no return is obtained. Examples of this sort of outlay are suggested in the items listed below. This list is not exhaustive, but will indicate the class of expense so treated. The rate being primarily a waste rate, all expenditure in the nature of dead loss falls into it.

Idle machine incidence.
Spoiled work.
Removals and rearrangements of plant, fixtures, etc.
Loss caused by stoppage of power plant.
"Extra" payment for overtime.

PRACTICAL SETTLEMENT OF MACHINE RATES.

The entire range of methods by which expense is localized and brought to a focus at

the tool point having now been enumerated, the practical settlement of the machine-rate factors will be considered next, and afterwards the nature of the arrangements that secure the keeping of such factors in touch with changes of organization or circumstances of manufacturing.

The relation of expense incidence to production centres is shown graphically by the following diagram (Figure 3), in which the factors above the dotted line represent "overhead" burden, properly speaking, and those below represent the incidence peculiar to each individual tool.

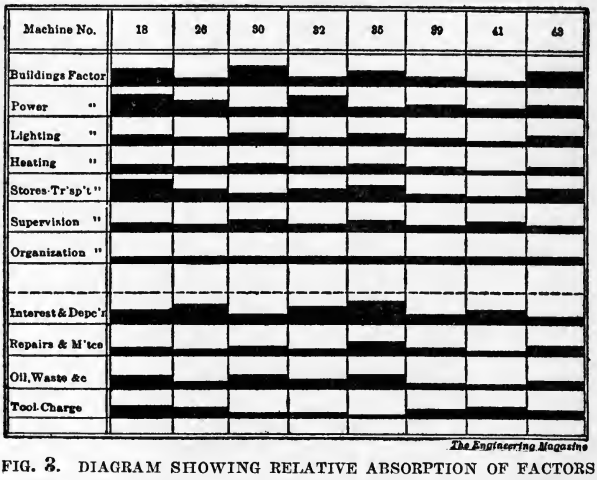

FIG. 3. DIAGRAM SHOWING RELATIVE ABSORPTION OF FACTORS BY THE DIFFERENT PRODUCTION CENTRES IN A SHOP.

In this diagram the vertical columns represent machines, and the horizontal lines represent the relative amount of each factor taken up, on the various bases of assessment, by each machine. If plotted strictly to scale, integration of the black portions vertically would necessarily give the relative differences of the resulting machine rates, while integration along the horizontal lines would give the total expense due to each factor that has to be borne by the shop. The object of the diagram is, however, merely to give a graphic realization of the way in which different machines absorb factors in different proportions, and it also serves to demonstrate how very far from the truth any "averaging" system of distributing burden must be. We shall now proceed with the practical methods used for determining the figures that are represented in this diagram of black rectangles.

In settling actual figures a schedule similar to Figure 4 is employed—a separate one, of course, being used for each shop. This schedule contains as many vertical columns as there are production centres in the shop. Items 1 to 6 represent data respecting each machine. Items 7 to 13 provide spaces for

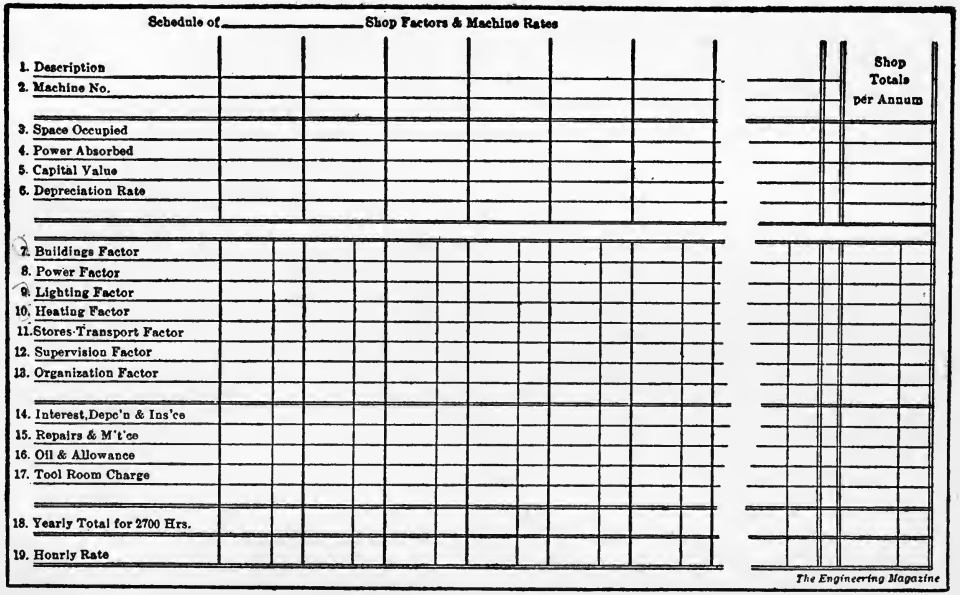

FIG. 4. SCHEDULE OF DISTRIBUTION OF EXPENSE ACCORDING TO PRODUCTION FACTORS.

the monetary value of the incidence of each factor on each machine. Items 14 to 17 provide for the charges peculiar to each production centre on its own account. The vertical column at the right hand summarizes the total amount that will be distributed of each factor when the shop is working the full amount of 2,700 hours, or whatever the usual working year may be.

The settlement of Items 7, 9 and 10 presents no difficulty. They are ascertained by a simple multiplication of the factor that has already been ascertained in terms of annual unit-value per square yard (or per square foot, which is more convenient), by the number of square feet occupied by the machine as set out above in Item 3. The power factor is ascertained in the same way by multiplying the unit-value per horse-power by the number of horse-power absorbed as Item No. 4. The organization factor will already be known, inasmuch as it is in the first place ascertained on a unit basis per production centre. The interest, depreciation, and insurance factor, Item 14, is most conveniently dealt with by means of an amortization table (referred to in connection with the land factor in the third chapter). The value of the

machine being known, its duration of life, say 10 years, is fixed by a competent authority, the residual or scrap value is deducted from the original value, and the remaining value can then be treated as a 10-year terminable lease, at 4 per cent or 5 per cent interest, as the usual local practice demands. This usual interest is increased to an amount sufficient to cover the insurance, so that the three items of interest, depreciation, and insurance can be dealt with in one annual factor, which will be an equal amount every year until the end of the assessed life of the machine.

Items 11, 12, 15, 16, 17 will then be left for settlement. Each of these is what may be called a "judgment" factor; that is, its allotment to particular machines cannot be reduced to a formula or universally applicable rule, but must depend on careful examination of the relative claims of each machine in the shop, in the case of Items 11 and 12, and on an advance estimate of actual requirements in the case of the others. One thing, however, must be pointed out. The error must not be made of supposing that because these factors are termed "judgment" factors, they are therefore to be re-

garded as simply "guess" factors. The method of settlement now to be described, if carried out by competent persons, will realize a very high ratio of accuracy, though slight modifications may be considered desirable from time to time.

SETTLEMENT OF STORES-TRANSPORT FACTOR.

It will be remembered that in the last chapter the lines on which the factor is departmentalized were indicated. The question was left at this stage—"The result of this preliminary mapping out of the field of stores-transport will be that each department will have:— (1) a share of the general stores-keeping expense proportional to the bulk of its transactions, (2) a number of particularized charges already seen to be connected with groups or kinds of production centres." The narrowing down of the departmental share entails two separate processes—localization and allotment. Figure 5 shows the nature of the first process. The vertical divisions represent all the production centres in the shop. Across all these we draw two lines, representing respectively general stores-keeping and general transport charges, some portion of which will be alloc-

able to every machine. Facilities that are confined to special groups of machines are plotted next. The method of doing this will be seen by the diagram, where the short lines represent craneage, conveying, and sub-stores, *of which the operation concerns only the product of those machines across which these lines are drawn.* Having thus localized the elements, the next step will be to give proportional value to the incidence so indicated.

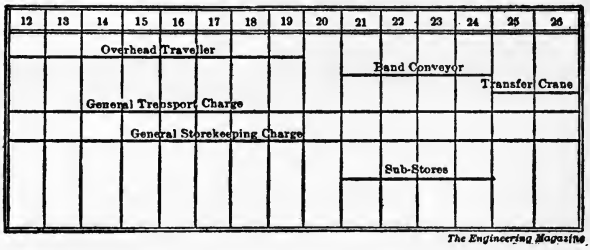

FIG. 5. LOCALIZATION OF STORES-TRANSPORT FACTOR.

This definite allotment is shown by Figure 6. It is assumed that this will be drawn on squared paper, to scale, in such a way that vertical distances are proportional to values expressed in money. The localized items are dealt with first. The expense of the overhead traveler, for instance, being considered equally incident on machines 12 to 19, and

being concerned with no other machines in the shop, the localization line of that item is thickened so as to indicate the proportionate share to be borne by each machine served

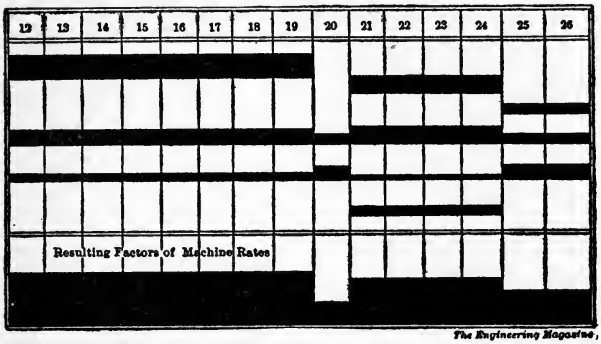

FIG. 6. APPORTIONMENT OF STORES-TRANSPORT FACTORS.

by it. The other localized items are then dealt with in the same way. A survey is next made of the general stores-keeping charges. On examination it will probably be found that variation in the bulk and quantity of product exists as between particular machines and groups of machines. Those, for example, which entail frequent call on the services of the stores department will obviously be allotted a heavier share than others. Thus heavy machine tools, on which a job lasts several days, will claim less of

the stores department's time than machines making product for stock in quantities. A careful comparison of the kind of work carried on by each machine in relation to the class of expense included in the general stores-keeping expense will lead to a close and satisfactory apportionment of that expense between the different machines.

The same plan is followed with the general transport charge, which, it must be remembered, does not include the special transport arrangements represented by the short lines on the diagram. Generally speaking it will be found that this item is not a heavy one after the special facilities have been localized out. But whatever the amount is, it is allotted between the various machines in proportion to their use of the services it represents.

The subsequent aggregation of the black portions of the diagram, if they have been drawn to scale, will yield rectangles of different heights as shown at the foot of Figure 6, and these, when transmuted into their money equivalents, will provide the figures necessary to insert in the schedule of machine rates against Item 11 as the allotment of the stores-transport factor.

THE SUPERVISION FACTOR.

The localization and allocation of the expenses comprised in this factor are dealt with in the same way as the stores-transport factor. The wages of "leading hands" and of inspectors are made incident on those machines to which they refer. The general expense, including proportion of works manager's salary and office expense, and that of the shop foreman, is then distributed to the various production centres on the basis of a careful consideration of their relative claims, having regard to the nature of the processes carried out at each of them. Thus some machines, as for instance a group of automatic machines under the charge of a leading hand (whose wages would already have been localized to that group), would bear relatively little of the general expense of supervision. Acquaintance with the run of the work of the shop and the ordinary routine of the foreman will make the task of the relative determination of this class of burden a comparatively simple one. The *method,* being precisely similar to that just described in connection with stores-transport, need not be further elaborated here.

THE REMAINING FACTORS.

The maintenance and repairs factor is arrived at by an estimate of the average annual expense of keeping the machine in good condition under ordinary circumstances of "fair wear and tear." This will not be a difficult figure to arrive at, if we admit that the cost of any wholly unforeseen catastrophe such as breakage is in the nature of a dead loss, and should be charged not against the machine, but against the "supplementary rate." The determination must obviously be made, as in the case of all these factors, not by an accountant but by an engineer.

The charge for oil, waste, and sundries of this class is usually based on a definite allowance of such stores, made by regulation, and under the record and control of the stores-keeper. It presents no difficulty.

The tool-room charge includes the supply of cutting tools, and the sharpening and maintenance of them. It will obviously vary considerably on different classes of machines. It must be so fixed as to represent fairly the average consumption of tools. In the case of expensive milling cutters of large size it will be high; in the case of a hack saw,

trifling. A close approximation to the actual cost will however be made if careful consideration is given to the usual run of the work on each machine.

The schedule being now completed, it remains only to aggregate the various factors that have been debited to each production centre and divide the total amount by the number of working hours per annum. The resulting figure is the hourly machine rate. It is sometimes urged that machine rates should be averaged into classes, so as to have three or four groups instead of a number of different rates. Such a contention is, of course, an absurd one. There is no more difficulty in having a number of diverse machine rates than in having a number of different rates of wages. It is just as easy to calculate one rate as another. The proposal is no doubt due to the "averaging" microbe that seems so difficult to eliminate from all questions of indirect charges.

In the next chapter the nature of the control accounts that keep the various fixed factors in touch with the actual expenditure they represent will be explained, and a general view of the working of the method will be given, diagrammatically and otherwise.

Chapter VI

CONTROL ACCOUNTS

A BRIEF review of the arrangements hitherto outlined will serve as an introduction to the subject of control.

The separation of the different items of indirect manufacturing expense into regular annual rents or payments for specific services was the first step. These annual rents when related to some basis of distribution, such as a square foot of floor space or a horse-power hour, are termed production factors. Secondly, these annual rents or charges are apportioned amongst the various machines or production centres, and to them are added certain factors individual to each machine, such as depreciation, repairs, etc. The aggregate of the charges found to be incident on each machine is divided by the working hours of the machine per annum, and the resultant is an hourly machine rate which represents the cost of all the indirect charges or services at the tool point.

But as all machines are not working all

the time, and consequently all the burden is not got rid of through the various tool points, the device of a supplementary rate is employed to take up this undistributed burden, together with certain other items of waste and dead loss, so that the proportion of wasted capacity to the useful capacity of the shop can be ascertained, and, if desired, expressed as an element of cost.

This is the bare theoretical outline of organization by production factors. The practical working demands, first, that a careful determination of the various indirect services or factors shall be made; and secondly, that adequate methods be adopted of securing that the factor-values shall be in continuous correspondence with the actual conditions obtaining in the shops.

A system of accounts controlling the production factors and their relation to the machine rates and the supplementary rate is, therefore, an important feature of this method of organization. Effectual control may be considered under four heads, viz.:—

1.—A means of observing how far the variable elements of expense included in the factors (such as repairs) are keeping within the amounts forecast.

2.—A method of dealing with discrepancies as they arise.

3.—A simple means of ascertaining the amount of burden that has not been distributed at the tool point, and its relation to burden that has been so distributed.

4.—Mechanism for varying the machine rates when the normal working year of 2,700 hours (or whatever basis has been fixed) is exceeded, as for instance, when overtime is being regularly worked or when double-shift or night-shift working has been adopted.

VARIABLE ELEMENTS OF FACTORS.

Every factor contains one or more elements of a variable character. Each, for example, includes the use of perishable property and involves maintenance and repair charges that may not always be forecast with accuracy. All factors, being in the nature of rents charged for specific services, correspond to ordinary property rents in the respect that while the rent charged is a fixed annual sum, the outgoings or expenditures are not uniform at all times. The owner of a row of houses, for instance, does not pocket exactly the same amount of net revenue every month or every year, nevertheless the

rent charged provides an average net revenue taking one year with another. This is precisely the principle on which production factors are based. The object to be attained is the fixing of factors on such a basis that, taking one financial period with another, they represent with fair accuracy what might be termed the "equalized" expenditure on each service.

This result will obviously not be attained immediately, nor without some experience of the variations that take place in expenditure. It is therefore important to provide some means whereby the actual expenditure on each separate service can be constantly observed and contrasted with the fixed factor that purports to represent it. There is no inherent impossibility in determining factors with great accuracy if the items of which they are made up are carefully and individually considered, but even then provision must necessarily be made for making sure that they are accurate, however carefully and conscientiously the determination may have been made. This provision takes the form of shop ledger accounts for each service, and for each production centre.

Figure 7 gives the form of one of these

BUILDINGS FACTOR A/c _____ Shop

Components of Factor		Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Dr. Actual Expense	Cr. Per Factor	BALANCES Not Distrib.	BALANCES Over Distrib.
INTEREST DEP'C'N INSURANCE	Actual Expense Dr.																
	Per Factor Cr.																
LAND FACTOR	Actual Expense Dr.																
	Per Factor Cr.																
REPAIRS & M'TCE	Actual Expense Dr.																
	Per Factor Cr.																
PAINTING	Actual Expense Dr.	—	—	—	$50	—	—	—	5	—	—	—	—	$55			
	Per Factor Cr.	$4	4	4	4	4	4	4	4	4	4	4	4		$48	$7	
WHITE-WASHING	Actual Expense Dr.																
	Per Factor Cr.																
CLEANING	Actual Expense Dr.																
	Per Factor Cr.																
												TOTALS					

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FIG. 7. EXAMPLE OF A FACTOR CONTROLLING ACCOUNT.

Figures relating to one component are filled in to illustrate the method of working the Account.

controlling accounts. On the debit side are placed, first, the invariable items, such as interest, depreciation, land factors, and secondly, the *actual* expenditure on maintenance, repairs, and all other variable items, as it is incurred, month by month.

The account is credited with the amount of each element of the factor as fixed officially. The difference between the two sides, at the end of the financial period, or indeed at any time, will be the excess of actual charges over the estimated charges distributed by the factor, or *vice versa.*

The discrepancies between the amounts as distributed by the factors and the actual expenditure on the items that go to make up the details of such factors require individual attention in each case. They are not necessarily unexpected or unforeseen. On the contrary, the principle laid down involves the necessity for over-estimating in some instances and under-estimating in others, if a general or "equalized" level of expenditure is to be represented in the factors. Leaving intentional discrepancies for a moment, the question of unexpected discrepancies needs some attention, inasmuch as they may involve, on occasion, a modification of the fac-

tor. If an unexpected discrepancy makes its appearance, one of two courses may be adopted: (1) the factor may be modified at once, so as to absorb the amount of the discrepancy; or (2) the balance may be allowed to accumulate in the ledger account to the end of the financial period.

The former of these alternatives is obviously to be avoided if possible. It is necessary only if the discrepancy is a grave one—sufficient, if the factor were modified, to give rise to an alteration in the machine rates. It would, of course, be rare that a miscalculation in a single element of a production factor would be so large as in itself to affect the hourly machine rates. Moreover, as production factors are always made up of several elements, it will commonly be found that small errors cancel one another to some extent. Interim alterations of factors will therefore be an infrequent operation. At the end of the financial period, however, the balances in the factor accounts will come under review. As already stated these will be of two kinds, those that have been planned and those that are unexpected. Of the former class may be instanced heavy expenditures on repairs of a building that it is desirable

to spread over several periods. Balances of this kind will in every case be carried forward to the next account. Balances due to unexpected fluctuations must be dealt with on their merits, and this involves a clear view of their relation to the facts of production.

The object of any system of cost accounting is to represent current facts and conditions. By reducing all indirect expense to payments or rents for specified services we obtain a clearer picture of what the complex activity of a works means, and it is an obviously desirable idea to distinguish between occasional and recurrent classes of expenditure, and so to arrive at a standard rent charge fairly representing the normal cost of each service. It is for this reason that the expenditure on, for example, the repair of a building, is not necessarily considered as incident wholly on the financial period in which it was incurred. Or to reverse the case, it may be foreseen that heavy repairs will be necessary in three years' time. In settling the repairs element of that buildings factor, therefore, it is fixed at a figure sufficiently high to over-distribute beyond the actual current year's expense, so that by the

time the repairs are undertaken a reserve is accumulated to meet their cost.

It will be seen therefore that over-distribution is equivalent to building up a reserve against future expenditure, or in other words, distribution by factors can be made to play the part of an equalization account.

The fundamental principle of production-factor organization is, therefore, not "averaging" but "equalization." This equalization takes place, not as between different jobs, but as between the cost of the same service at different financial periods, provided, of course, that the amount of the service rendered does not vary.

Discrepancies due to conditions that have been foreseen will therefore be dealt with as being in the nature of reserves designed for equalization of the cost of services, where the expenditure on these is necessarily intermittent, although the service itself is both continuous and invariable. Such discrepancies, in the form of debit or credit balances, will therefore be carried forward to the next financial period.

Unexpected discrepancies are on a totally different footing. In general they will be errors. But they will be errors of perfectly

definite and known amount, and to that extent under control. If they are serious errors they will be rectified as soon as discovered, by a modification of the factor and of the machine rates. We have therefore only to consider what is to be done with minor errors, as, for instance, the example shown in Figure 7, where a small undistributed balance in respect of painting remains at the end of the financial period (here considered as twelve months). Generally speaking there will be a number of such small discrepancies to be dealt with at the end of each financial period. The question of what is to be done with them is therefore an interesting one.

Strictly speaking, it is obvious that they should have been thrown onto work during the financial period in which they were incurred. This being so, it is equally obvious that they have nothing to do with the work in any other period. To carry them forward is merely to make a double error. Production in the first period having been unduly relieved of certain items of cost, to carry forward would be to burden production unduly in the second period in an equal but opposite degree. Theoretically, therefore, such errors

should be limited to the inaccuracy they have already caused and not made the source of future inaccuracy.

It has already been pointed out, however, that these discrepancies will, in no case, be serious amounts. Practical considerations may therefore make it desirable to deal with them in an arbitrary manner. As they cannot be thrown onto work already done, only two methods of disposing of them remain. They can either be carried forward, or thrown into the supplementary rate for the last month of the financial period. This latter measure has the advantage of getting rid of them in a harmless manner, but it involves a dangerous precedent. It is, in fact, an example of the vicious principle of getting rid of expenditure "somehow" that is the prevailing characteristic of averaging methods.

Carrying forward, though objectionable from the point of view of pure theory, has practical advantages that outweigh the objections. It places unforeseen discrepancies on precisely the same footing as those that have been deliberately planned. As the only way of escape for undistributed expense is, in this case, through balances remaining in the factor accounts at the end of the financial

period, it follows that all such items will be the subject of very careful scrutiny at the end of each financial period. These balances will, in fact, become the mirror in which the accuracy of the factor will be reflected, without exception. This is a practical advantage that outweighs the slight theoretical inaccuracy introduced by the carrying forward of small balances from one period to the next.

Accounts similar to Figure 7 are kept for each production centre. In this case the items will be as detailed in the section on the "Practical Settlement of Machine Rates," the charges actually incurred for repairs and similar variable items being debited to the machine, month by month as incurred, and contrasted with the amount distributed by the machine rate. Such an account forms a most valuable life-history of the machine and is in accord with the modern principle of giving close attention to the cost, capacity, and output of each machine tool.

The general object of these control accounts is to determine the fixed elements of annual cost of each service, forecast the variable elements, and keep a close watch on the correspondence between the forecast and the

actual expenditure. Further, they provide a means of equalizing intermittent kinds of expenditure and making it bear fairly and equally on the work.

THE SHOP BALANCING ACCOUNT.

It was pointed out in the beginning of the installment that a simple means of ascertaining the amount of burden that had *not* been distributed at the tool point was desirable, for the purpose of ascertaining its proportion to the amount so distributed.

The diagram, Figure 8, shows the arrangements for doing this. The central feature is the "Shop Waste or Balancing Account." This ascertains the amount of machine rates not distributed on work—that is, the ratio of wasted to utilized capacity. The balancing account is debited with the monthly aggregate value of the various factors, and is credited by machine earnings. It will be obvious from what has already been said as to the relations of the machine-rate factors to the production factors, that if all the machines work full time the account will balance exactly. If they have been idle 25 per cent of the time, a quarter of the total burden will remain undistributed. But it will be remem-

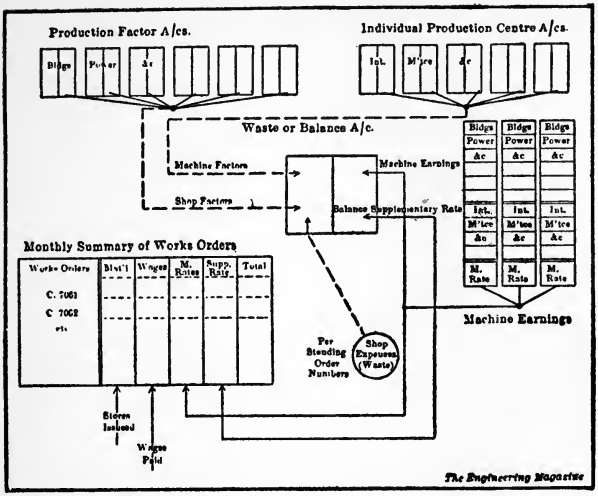

FIG. 8. DIAGRAM SHOWING CONTROLLING ACCOUNTS.

The various ledger accounts at the top of the diagram correspond with the several factors making up the machine rates. Consequently if all the machines work full-time, these ledger accounts are exactly balanced. For practical convenience an intermediate account called "Waste or Balance Account" is made use of, in which the debits and credits meet for ascertainment of the balance due to idle time, which is distributed as a supplementary rate.

bered that all kinds of expenses of the nature of waste and loss fall into the supplementary rate. Among these were enumerated—spoiled work, loss caused by stoppage of power plant, extra payment for overtime, etc. These and similar items are collected

by means of standing-order numbers and debited to the waste or balance account and as there is no factor in any machine rate corresponding to them, they can necessarily be distributed only in the supplementary rate. The latter is made up therefore of:—

1.—Factor values not distributed through machines rates.

2.—Expenses per standing orders due to losses of various kinds.

Machine rate earnings are collected and credited to the balance account by means of the monthly summary of work orders shown in the diagram, which summary also serves to make the distribution of supplementary rate over the various orders that have been worked on during the month. When all the orders with the amounts charged against each for material, wages, and machine rates have been tabulated, the total of the latter is ascertained and placed to credit of the balance account, which has already been debited with factor values and standing-order items as explained above. A balance is then struck and the ratio of the balance to the amount distributed is ascertained. This can be expressed as a percentage figure of the amount distributed, in which case the

amounts chargeable to each works order are rapidly calculated on a comptometer or other machine and placed in the vacant column in the monthly summary sheet. If preferred, the balance may be distributed on an hour basis, which necessitates, however, that the total hours on each order be known. But, as before pointed out, this rate expresses only a ratio of unutilized or wasted capacity to utilized capacity, so that either distribution on an hour basis or by a *pro-rata* increase of the amounts already distributed can be employed, as convenience dictates. The hour method is preferable, but involves more work. Either method is equally correct.

When this distribution has been made the whole question of the actual incidence of the factors on work will have been cleared up for that period. It will be observed, however, that the supplementary rate is only distributed on each works order as a whole on its monthly total and not upon its constituent jobs. Thus the total cost of building a lathe will be expressed in material, wages, machine rates, and supplementary rate, but where detail costs are taken, they will not have any portion of the supplementary rate attached

to them. Thus, the cost of planing the bed would consist of wages and machine rate alone. It would, of course, be possible to distribute the supplementary rate on individual jobs, but it would serve no useful purpose whatever. If such information were wanted, a simple calculation would give it, if we know the month it was done, and the percentage ratio, or the supplementary hour rate for that month. It is difficult to imagine, however, any circumstances in which such information would be of service. All the elements of actual cost are already represented when we know the wages and the machine time. The ratio of utilized or unutilized capacity has no connection with any purpose for which *detail* costs are commonly required.

It may perhaps be advisable to point out that the function of the balance account is merely that of *measurement* of the amount of wasted indirect services to production. It is necessary to emphasize this, as it might be hastily assumed that the different factors, by being debited together to this account, were in fact thrown into a lump sum by that means and so distributed. That this is not so will be seen if it is considered that the

actual distribution is not made by means of the sums so collected, but by the machine rates which are themselves made up of diversified factors. All that the balance account does is to provide *a means of subtracting the amount so distributed from the total, so as to ascertain the amount left undistributed.* The latter sum consists of factors all fused together, it is true, but as this remnant is waste, and belongs to no distinguishable items of work, there is no longer any purpose in seeking to keep separate the elements of which it consists. The balance account is a convenient but not a necessary device for saving time. The credits might, in theory, be made direct to the factor accounts themselves and a number of separate balances struck. But no useful purpose would be served, because the separate items representing waste would eventually have to be aggregated to ascertain their ratio to utilized factors. The result would be exactly the same as that obtained with the short cut of the balance account.

EXTENSION OF WORKING HOURS.

In every production factor there are certain components that are invariable and

have no relation to the volume of output, and others that are variable according to the output, or rather according to the period of working. Speaking of the question of a shorter working day and the obstacles that stand in the way of its realization, Professor Chapman has recently pointed out* that

> The closest limit is imposed upon the reduction of hours by the heavy interest and depreciation charges with which the product of a machine is burdened when it works only a fraction of the time for which these charges must be paid. Buildings deteriorate in value at least as much when shut up as when occupied; machinery continues to wear out, and sometimes rapidly, when it is idle; and the reserve fund necessary because the market may contract at any time, and because machinery may at any time be rendered obsolete, is independent of the length of the working day.

On these considerations is based an argument for double or treble shifts.

> The shifts for foremen and the management generally, which would have to be strengthened, might be arranged to run over a portion of two operatives' shifts, so as to cement the new work to the old.

Certain of the services, therefore, which are reduced to annual rents or factors under the present method will only be justly repre-

*Address to Economic Section, British Association, Winnipeg, 1909.

sented by those rents or factors as long as the normal working period, (say 2,700 hours per annum) *is not exceeded.* If, for example, a double shift were introduced, it is evident that the machine rates if unaltered, would distribute double the amount of the factors debited to the shop account, which would make the resulting balance a negative one, and the supplementary rate a minus quantity. This would, of course, be an absurdity. But beyond this, a little consideration will show that certain of the factors themselves would no longer be correct. The *annual* value of the land and buildings factors would not, indeed, be altered, because no greater claim is made on these services whether the shop is working normal time or continuously day and night. But all factors containing variable elements, such as the power factor and that representing stores-transport, would be modified, since some components of those services would cost more for double shift than for normal working. The "strengthening" of the supervising staff referred to above would also necessarily modify that factor. In short, the whole internal economy of most of the services would be greatly changed.

This is as it should be. When working conditions are so wholly changed the organization becomes necessarily modified, and if this is followed by costs, comparison of the new factors with the old will provide a view of the relative efficiency of the two methods such as can be obtained in no other way. Or, rather, the composition of the factors as arranged for double-shift working will bring into full relief the direction and the extent to which increased efficiency is attained. No averaging or percentage method of dealing with indirect charges will provide information of this class at all. All that is revealed by such a method is that the percentages have fallen—a fact that is obvious enough already—but that certain elements are stationary and that some have increased is not brought to light. Worst of all, no guidance is given as to the nature or extent of the increases due to extended period of working.

On the production-factor method, the precise bearing on production of questions of interest and depreciation, building rents and charges, and all other invariable factors is visible all the time. The extent of gain to be made by intensifying production can be ascertained or forecast without any special

searching or analysis. The components of every production factor, and also of every machine rate, *being always preserved separate and distinct,* the relative influence of such charges can be read almost as in an open book.

It must not be supposed that the working out of new factors for double shifts is as complex an operation as the original settlement of production factors. On the contrary, all the components of each factor being kept separate, modification of *those that involve increased expenditure* is all that is necessary, and the nature and extent of such additional expenditure will very quickly be ascertained, and substituted for the original figures. The reconstituted factors, divided by the new working period, say 5,400 hours, will provide the machine rates necessary for double-shift working.

While the settlement of factors for double or treble-shift working, or indeed, for any *definite* increase in the period of production, is as easy as or easier than the original determination for normal-period working, the same cannot be said of what may be termed "accidental" overtime, i. e., overtime which is irregular and intermittent. In averaging

or percentage methods, overtime presents no difficulty, for the simple reason that no account is or can be taken of idle machines, but burden is averaged over all work without regard to the question whether the expenditure has contributed in the slightest degree to the actual items under manufacture. On such methods the shop may be half-idle during a portion of the month and working overtime during the remainder of the month, but every item of work gets just the same average of burden, which is really equivalent to saying that the work in the idle period is escaping burden and the work in the busy period is being laden with burden with which it has nothing to do. Consequently, whatever else they may be, such cost figures are not, in any significant sense, genuine costs.

A similar state of things with production factors would, of course, maintain production costs, i. e., machine-rate figures, at their ordinary value, only the supplementary rate representing waste being affected by the idleness of half the shop during the first period.

Nevertheless, the question is one of great practical difficulty, because the conditions sought to be represented are in themselves complex. Normal machine rates are fixed

for the purpose of distributing, in a normal year of 2,700 hours (or whatever the figure may be), the expenditure on the various services also calculated for a period of 2,700 hours. The difficulty arises if the period of 2,700 hours is exceeded, as in occasional and intermittent overtime, and it arises from the fact that certain of the components of the services remain stationary, whilst others do not, precisely as explained in regard to double-shifting working. If, therefore, we have calculated our rates on a basis of 2,700 hours and we actually work 2,800, without modifying our machine rates, it is evident that there will be a departure from accuracy in respect of the components such as interest, depreciation, building factors, etc., which are stationary in value—that is, do not vary whether fewer or more hours are worked in the year. The extra distribution of other components will be balanced by extra expenditure on them.

Where overtime is accidental and temporary, and does not in any one year amount to more than a few per cent. of the working hours (say 2,700) which constitute the normal basis, no serious disturbance ensues; but should overtime become a regular feature,

then this amounts to an extended working period "within the meaning of the act," and must be met by modification of rates as in the case of a double shift already described.

Owing to the importance of a thorough knowledge of the bearing of overtime on production, which at present is a much debated point, and on which no light can be thrown by any percentage system, I am in favor of isolating overtime operations from those of normal working, a process which would certainly make a very interesting study possible. I am hopeful that further investigations may presently allow this to be done in connection with production factors, by comparatively automatic arrangements, but at present no convenient and easily worked method has been arrived at.

The whole field of manufacturing production has now been covered, but the question of selling expense is so closely connected, that, although not of course amenable to any connection with machine rates or other shop devices and conditions, the subject cannot be regarded as closed without some consideration of this class of expense. In a final chapter, therefore, some hints on the matter will be offered.

Chapter VII

COSTS IN RELATION TO THE FINANCIAL BOOKS

THE final court of appeal in all factory accounting is, or should be, the financial books, which bring their record of operations to a focus in three final accounts—the Trading Account, the Profit and Loss Account, and the Revenue Account. Manufacturing costs, whether interlocked with the financial books or treated as entirely separate and subsidiary, should be regarded as an attempt to present an amplification and detailed explanation of the condensed figures set out in these final accounts.

Generally speaking, these accounts deal with three different aspects of profit, viz:—(1) gross manufacturing profit, (2) net trading profit, and (3) disposal of profit in dividends, etc. These accounts are sometimes called by other names, as for instance, Manufacturing, Trading, and Profit and Loss, in-

Dr.	TRADING ACCOUNT		Cr.
Work in Hand at beginning of period	$ 10 000.00	Work in Hand at end of period	$ 10 426.00
Stores " " " " " "	3 000.00	Stores " " " " " "	2 891.00
Purchases during period	2 876.00	Sales during period	25 103.00
Wages paid during period	11 813.00		
BALANCE = Gross Profit for period	10 731.00		
	$ 38 420.00		$ 38 420.00

Dr.	PROFIT & LOSS ACCOUNT		Cr.
Repairs & Maintenance	$ 400.00	Gross Profit from Trading A/c	$ 10 731.00
Interest & Depreciation	1 020.00	Discounts taken	50.00
Rents, Taxes & Insurance	130.00		
Management & Supervision	300.00		
Office & Selling Expenses	2 300.00		
Packing & Freight	400.00		
Discounts allowed	50.00		
BALANCE = Net Profit for period	6 181.00		
	$ 10 781.00		$ 10 781.00

Dr.	REVENUE ACCOUNT		Cr.
Interest on loan Capital	$ 1 290.00	Net Profit from P.& L. A/c	$ 6 181.00
Legal Expenses	121.00		
Directors Fees	200.00		
Reserve Fund	1 600.00		
Dividend for Period	2 970.00		
	$ 6 181.00		$ 6 181.00

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FIG. 9. SPECIMEN EXHIBIT OF THREE FINAL ACCOUNTS.

In engineering works, additions to plant and repairs to tools, buildings and plant are frequently carried out by the shops. In such cases the value of the work would be credited to trading account. In the accounts above and in the discussion following it is assumed for simplicity that a purely manufacturing business is done in the shops, repairs, etc., being contracted for with other firms. The figures given are purely illustrative and do not represent any actual case.

stead of Trading, Profit and Loss, and Revenue; but however styled, the functions of the three final accounts are, generally speaking, substantially as above stated.

The three specimen accounts given in Figure 9 will serve to show the usual scope of each. In the first one it will be seen that by setting the value of stores and work in hand at the end of the financial period against their value at the beginning of the period, plus the amount of stores purchased and wages paid, we virtually ascertain how much the total value in hand has increased or diminished since the last stock-taking. It will usually be found to have diminished by reason of deliveries effected, and it will be obvious that if we were to credit the account with the *cost* value of such delivered orders, it would exactly balance, and show neither profit nor loss. As, however, the account is credited at *sale* prices it follows that a balance corresponding to the difference between cost and sale prices—that is, to gross profit—will appear.

In the second account, the gross profit transferred from the previous account is subject to a process of diminution by setting against it the indirect charges or establish-

ment expenditure, some of which are really costs of production and some are charges arising from selling and distributing the product. The long established practice of collecting all these into the same account has given rise to much of the confusion that surrounds the question of charges, especially in the matter of distinguishing between shop and general charges. The third account deals only with the disposal of profit and not with how it was made. It does not need further consideration at the present moment.

The reason why Trading account is arranged as it is will be clear when we remember that very few auditors have any faith in the apportionment or distribution of charges, and prefer to deal with figures which have the merit of being definite, as the direct expenditure on wages and materials usually is, and to set against these the equally definite figure of sales—the difference between the two representing, it is true, no complete fact, but giving, nevertheless, a relation of well understood significance, viz:—gross profit.

It should be observed, that for financial purposes it is not necessary to have any knowledge of what are usually known as costs. It is sufficient to know the sale price

of each order, and when all these are aggregated, forming a total of sales for the period, the difference between values in hand at the beginning of the period and the values in hand at the end of the period (plus what has been put in during the period) gives a net figure which is really equivalent to *the prime cost of all the orders in a lump sum.*

To ascertain profits, therefore, it is not necessary to know individual costs, but only individual sale prices, if a stock-taking valuation is taken at the beginning (or end) of each financial period. This ascertainment of results in the lump at the end of a year or half year is still relied on by many firms.

But just as the figure representing total sales is an aggregation of a number of individual sales, so the balance representing cost of orders is really an aggregate of a number of individual costs. If therefore an accurate system of prime costs is in use, the trading account could be very simply checked by making a list of all orders which have been completed and invoiced and placing the prime cost against each. It is clear that this list, if set against a list of the sale prices, would show a difference identical with the gross profit exhibited by the trading account.

In the same way, if a perfect system of distributing all the indirect charges incurred in production were in use, and a list were to be prepared of all delivered orders, showing:—

1.—Their prime cost . . . wages and materials.

2.—The indirect shop charges.

3.—A due proportion of general and selling expense,

then the aggregate of these items for all orders completed and delivered, when set against the sale prices, would show a difference or balance exactly corresponding to the net profit shown by the profit and loss account.

We are now in a position to realize what an entirely different procedure is commonly undertaken with regard to presenting the details of these two great divisions of manufacturing cost represented respectively by these two accounts. No one has ever suggested that prime costs should be averaged. No one ever argues that if $200 has been spent on twenty articles, then the cost of each can be safely considered at $10, unless indeed the product is absolutely uniform. Such a suggestion would be treated with ridicule, be-

cause obviously the only use of detailed costs is to reveal the *relative* amounts of wages and material that the different orders have absorbed. The incidence of labor-cost and material-cost on orders is too obviously individual and unequal for us to think of averaging prime costs.

When, however, we come to the second and third elements of cost, which form the subject-matter of the profit and loss account, an entirely different plan is commonly pursued. Notwithstanding that the expenditure under this head frequently equals and sometimes surpasses in value the item of wages, which are generally so carefully traced and allocated to individual orders, it is a very usual practice to average this large class of expense, and to express its incidence by a simple percentage either upon wages or upon time.

That this plan is entirely misleading there can be very little doubt, because few of the expenses in the profit and loss account have any relation either to each other or to wages or to time. To rely upon an arbitrary established percentage which may actually be either much over, or much under, the real incidence of a number of varied factors on a

particular order, may be a good way of getting rid of figures and giving an air of finality to cost accounts, but it is very little else. As a guide to actual profitableness of particular classes of work it is valueless and even dangerous.

If, however, the greater part of indirect expense could be reduced to a *real* incidence on particular jobs, we should find ourselves at once in presence of new and important classes of facts. Foremost amongst these is the question of inefficiency due to idle manufacturing facilities, or, as I prefer to call them, "Production Centres." Whether such production centre be a machine, a pattern maker's bench, or a plain floor area in an erecting shop or a foundry, it is obvious that if it be idle and unoccupied in production, money value is as surely being wasted as if wages were being paid to a number of men who were entirely unoccupied. To allow the incidence of such wasted resources to become attached to work by means of an averaged percentage, on whatever basis the latter is calculated, is grotesque in its inadequacy to represent actual facts.

Nor is it less absurd to include selling expense in the same percentage with manufac-

turing expense. The two have no relation whatever to one another. The routine, the methods of selling, and the expenditure on different classes of articles may and often do vary considerably. It may easily happen that the efforts and the expenditure to obtain business in particular lines are so great that the result is not by any means worth the trouble. How is this important fact realized by any plan of averaged percentages? If such facts and those just referred to (idle production centres) are not brought out separately and distinctly, it may well be asked,—what is the use of an averaged percentage at all? The answer is that in certain very limited conditions it is of value, but that where more than one class of article is being manufactured it becomes merely a remarkably intricate device to give misleading information.

The proper relation of costs to the trading account and the profit and loss account may now be summed up. These two accounts give results *in bulk*. Prime costs are the details of labor and materials on the individual orders, which have passed out of trading account by reason of sales. Complete costs *should be* the prime cost plus the accurately detailed incidence of shop charges, general charges

and selling expense, also on each individual order. Manufacturing cost plus selling cost should, then, contain several separately expressed factors as follows:—

1.—Prime cost . . . wages and materials.

2.—Shop burden, which will include a proportion of general or administrative expenses.

3.—An inefficiency factor, or supplementary rate, representing loss of efficiency due to idle production centres and wasted facilities of manufacturing.

4.—Selling expense (also including a proportion of general or administrative expense) based on the actual absorption by each *class* of product, of the different items of selling expense.

It will probably be objected that this is a very complex and formidable way of presenting costs. The answer is that in actual practice it is not as difficult as it looks, but a still more complete reply to the objection is that no method that fails to provide the information in this detailed form is anything more than a sham. *No facts that are in themselves complex can be represented in fewer elements than they naturally possess.* While it

is not denied that many exceedingly complex methods are in use that yield no good results, it must still be recognized that there is a minimum of possible simplicity that cannot be reduced without destroying the value of the whole fabric. The snare of the "simple system" is responsible for more inefficiency and loss than is generally realized.

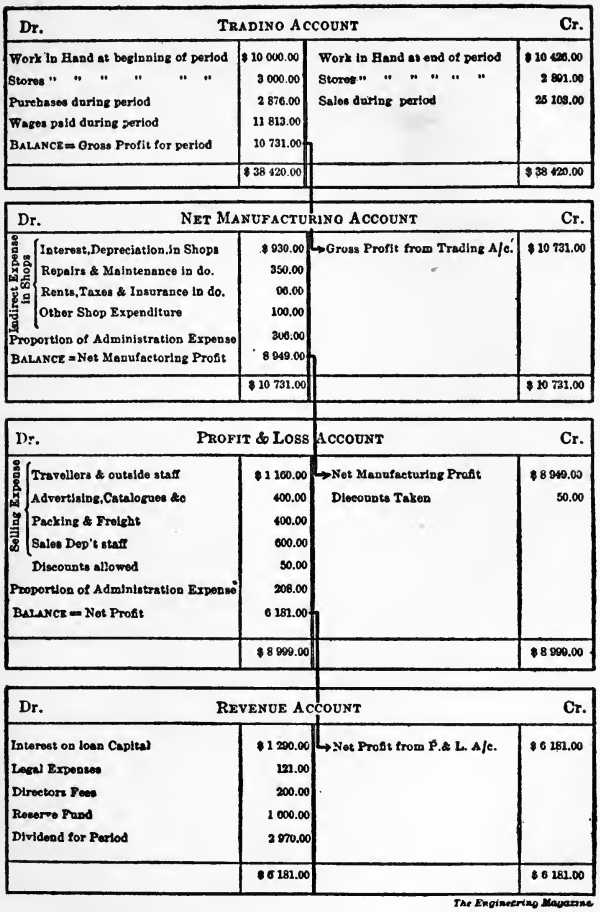
Works accountants would be better able to realize this point of view and enforce it on those to whom it is a matter of importance, if, instead of collecting all items of indirect expense into profit and loss account, they were to divide the latter into two accounts, thus providing an intermediate account between gross profit and net profit. (See specimens in Figure 10). In such case trading account would contain prime cost only; the new account, which might be called net manufacturing account for want of a better title, would correspond with elements (2) and (3) of cost, while profit and loss account would correspond with element (4). The items given in the specimen accounts will explain this disposition, the only special point being the division of general and administrative expense between the shops and the selling department on an adequately thought-out basis.

Arranged in this way the place and position of each of the elements of cost in relation to the final accounts is clearly seen, and also the utter inadequacy of "simple systems" to represent all these different factors. It may even be said that a measure of the success of any system of collecting costs is thus provided, because complete agreement with these accounts at each stage must be insisted on as a means of verifying the accuracy of cost figures.

SELLING EXPENSE.

The true relation of selling expense to production can be grasped most effectually by picturing the works and the selling department as being located in different places. With the former in the country and the latter in a more or less distant city the relation is at once seen to be perfectly simple—namely, that there is no relation at all! From this consideration it is not very difficult to realize that the mere fact of their happening to be located in the same place or in near neigh-

In the accounts exhibited on page 175, the "administration expenses" consist of office rents, staff salaries, management expenses, and similar items common to the manufacturing and selling departments and not separately allotable to either. Compare these accounts with those on page 164.



Dr.	Trading Account		Cr.
Work in Hand at beginning of period	$ 10 000.00	Work in Hand at end of period	$ 10 426.00
Stores " " " " " "	3 000.00	Stores " " " " " "	2 891.00
Purchases during period	2 876.00	Sales during period	25 103.00
Wages paid during period	11 813.00		
Balance = Gross Profit for period	10 731.00		
	$ 38 420.00		$ 38 420.00

Dr.	Net Manufacturing Account		Cr.
Indirect Expense in Shops: Interest, Depreciation, in Shops	$ 930.00	Gross Profit from Trading A/c.	$ 10 731.00
Indirect Expense in Shops: Repairs & Maintenance in do.	350.00		
Indirect Expense in Shops: Rents, Taxes & Insurance in do.	96.00		
Indirect Expense in Shops: Other Shop Expenditure	100.00		
Proportion of Administration Expense	306.00		
Balance = Net Manufactoring Profit	8 949.00		
	$ 10 731.00		$ 10 731.00

Dr.	Profit & Loss Account		Cr.
Selling Expense: Travellers & outside staff	$ 1 160.00	Net Manufacturing Profit	$ 8 949.00
Selling Expense: Advertising, Catalogues &c	400.00	Discounts Taken	50.00
Selling Expense: Packing & Freight	400.00		
Selling Expense: Sales Dep't staff	600.00		
Discounts allowed	50.00		
Proportion of Administration Expense	208.00		
Balance = Net Profit	6 181.00		
	$ 8 999.00		$ 8 999.00

Dr.	Revenue Account		Cr.
Interest on loan Capital	$ 1 290.00	Net Profit from P. & L. A/c.	$ 6 181.00
Legal Expenses	121.00		
Directors Fees	200.00		
Reserve Fund	1 600.00		
Dividend for Period	2 970.00		
	$ 6 181.00		$ 6 181.00

The Engineering Magazine

FIG. 10. SPECIMEN EXHIBIT SHOWING SUBDIVISION OF PROFIT AND LOSS ACCOUNT. SEE FOOTNOTES PAGE 174.

borhood does not make their mutual relations any more intimate.

It is the more important that this fact be fully realized, since the types of selling organization are far more varied than those of manufacturing organization. Even in the same concern some of the product may be on an entirely different footing as regards selling expense from other items. For example, a large section of the business may consist of a standard product for which there is a steady demand, arising from the reputation of the firm for that product, and requiring no special and expensive efforts to secure business. Another portion may consist of a specialty, recently introduced, and taking a large amount of time, attention, advertising and demonstrating expense, installations on approval, etc., to effect sales.

It will be evident that any method of dealing with selling expense must distinguish between these two classes of sales, and not average the total selling expense over total sales. In other words, selling expense must be dealt with by classification of product, having in view, not the difference in cost of manufacture, but difference in calls on the expenditure of the sales department. All

product should be debited to the sales department at works cost—what happens thereafter is no concern of the productive departments, and the figures relating to the two classes of activity should never be mingled. The principle of "keeping separate" is as important here as in all other branches of technical accounting.

As this whole discussion is intended to deal only with production, the question of selling expense cannot be further enlarged upon, the subject being a large one and deserving separate treatment. It will be sufficient for our present purpose to emphasize the principle that production expense ends at the works gate. In the sample accounts presented here, it will be observed that selling expense is grouped by itself in the profit and loss account. This is as it should be, because it represents a wholly different class of activities which require to be dealt with on their merits. Manufacturing and selling call for the exercise of quite different faculties, rarely found combined in the same individuals.

SUMMARY OF THE PRODUCTION-FACTOR METHOD.

The method of organization by production factors and their connection with production

centres has now been outlined. We have seen how a considerable number of items hitherto considered as indirect or floating charges are really possible of consideration as in the nature of rents chargeable against production centres, and thence passing out onto the work performed by those centres. We have seen that production is made up of services, of which labor is only one. And we have also seen that inefficiency due to slack production can be expressed as a separate factor of cost. Further, we have seen that selling expense is not reducible to the same basis as production, but that it has laws of its own that cannot be neglected.

It will be obvious that costs developed on this plan are a more subtle engine of discrimination than any hitherto available. The production-factor method gives free and independent play to the various elements of cost in a manner that is not possible of realization on any method that first drags heterogeneous expenditure forcibly into lump sums, and then deals with these as if the only object were to get rid of them on work—no matter how, as long as they are got rid of. On the contrary, we have seen that each production centre bears its own burden, and pays its own

series of rents quite irrespective of what its neighbor is bearing, and this without reference to whether the shop is slack or busy. Further, the effect of waste of factors, as for instance a shop only half full of tools, or in which tools are unnecessarily and wastefully isolated, shows itself as a separate element of cost, or rather it goes to swell the supplementary rate which is to a considerable extent an inefficiency element of cost.

The control over the form of costs obtained under the system of organization by production factors, though important, is not the only, or perhaps even the greatest, benefit attained by this method. The point of view from which production necessarily becomes regarded is an even more important matter. A clearer insight into what manufacturing really implies is gained when we begin to look at a works or factory as an assembly of centres each absorbing special services or "production factors" independently and unequally. We come to regard a machine, not as a mere inert piece of ironmongery but as a kind of living entity having as nearly a definite price as the work of an operative has a definite price. This price moreover is no arbitrary one, but is compounded of a

number of separate and independent factors, which it is possible under certain circumstances to vary and reduce.

The modern plan of laying out everything as far as possible in advance, of predetermining results, and of rigorously comparing what has taken place with what was expected to take place, has a close relation to this form of organization. Until the idea of planning became familiar, the idea of mapping out the activity of a complex factory in definite production centres would have seemed impossible of attainment. And it is equally true that this method of organization reacts in no feeble way on the possibility of predetermined results of actual manufacture, since it permits every extension and every rearrangement to be reduced in advance to figures—definite, not as affecting particular groupings of indirect charges, but as bearing on the hourly work of every single machine or production centre.

The most noticeable tendency in engineering manufacture at the present time is a desire to reduce all operations to definite standards. "The machine-shop problem" as Charles Day said recently in the pages of THE ENGINEERING MAGAZINE "in its most ele-

mentary sense, resolves itself into one of removing chips from the parts on which work is to be done.*'' And in this direction ''shop practice is nearing a stage approaching standardization,'' largely because ''the records that have been secured and the standards that have been established by machine-tool builders and the concerns manufacturing tool steel are now so complete that their maximum capabilities can be foretold within reasonable limits.''

These developments are part of the general progress towards regarding manufacture as a step-by-step series of definite predeterminable operations—a tendency that cannot be fully realized until the vague incidence of indirect charges is, once for all, got rid of and the maximum and minimum range of incidence on definite production centres substituted for it. When along with the ''chip-removing'' capacity and power absorbtion of every different type of machine we begin to realize that it has a natural machine rate, which can be forecast within certain limits even before it is actually installed in a shop, a good step forward will have been made in

* ''Machine Tool Practice for Maximum Production,'' in THE ENGINEERING MAGAZINE for July, 1909.

the direction of final standardization. Only the accumulation of records and of compared experience can make this possible, but it will be allowed that *a general acceptance of the principle of organization by production factors would have the effect of making known the usual or standard values of such factors under conditions of good practice,* and that therefore as soon as the elements of cost, power, durability, space and attendance of any new machine were determined, *its normal rate under conditions of efficiency and economical installation and working would also be predeterminable with sufficiently close accuracy.* In so far as such theoretical rates were not realized in actual practice it would suggest a prima-facie case for inquiry into causes.

It may be objected that these factors are subject to change. That is their merit. The belief in the possibility of a simple system, that, once established, will give accurate results for all time, is based on sheer inappreciation of the problem. In a works undergoing changes and modifications the actual factors of production are constantly being varied, *whether we willfully shut our eyes to the fact or not.* The merit of the production-

factor system is that it provides a method of quickly taking note of such changes and allowing their influence to become manifest, instead of ignoring them, and dwelling in the false security that changes of manufacturing method have not shifted the incidence of factory burden. Every such change does so, and just how far and what direction it works is a very important matter.

When someone unfamiliar with manufacturing is taken into a machine shop, his impression is that of a wonderful activity of which he can discern neither the plan nor the guiding strings. Those having an inside knowledge based on older methods of organization are not as much advanced beyond this point of view as might be imagined. The shop presents itself to them as a number of machines and a number of men, it is true, but they can only picture a very limited portion of the total activity as definitely connected with work performed. This portion is represented by the hourly wages of men actually engaged on orders; all the rest of the activity and all the rest of the expenditure, seen and unseen, is blurred into a vague and indefinite perception and lost in the mists of "indirect expense." The narrowing down of

indirect expense to close association with production centres is therefore not only important from the point of view of costs, but promotes clearer ideas of organization and helps to answer in a very definite way the ever pressing question "where all the money is going to."

As has been already referred to in these chapters, one of the obstacles to a clear view of the true relation of indirect charges to work has been their *continuous* character. Whether work is being done, or not, the larger portion of such charges have to be met, if not out of profits, then at the expense of capital. Unconsciously the argument is made that if these charges are always pressing on the undertaking whether work is being done or not, then they cannot have any real connection with particular items of work. But *what is really being paid for is the capacity to produce,* and whether that capacity is being wasted or not it still has to be paid for either out of profits on the unwasted portion or out of capital. When, however, we do employ that capacity it seems fairly obvious that the cost of the portion employed passes into the work done as an element of job cost.

In this connection it must never be forgot-

ten that the "Supplementary Rate," the moment it rises above the normal, represents shop inefficiency. It represents that portion of the cost of the job which is due to abnormal conditions. By expressing this amount separately, we disentangle true costs from apparent costs in a way that has never before been possible. In other words, the supplementary rate is closely identified with the continuous character of indirect charges, and it overcomes the obstacles to a clear view of their true relation to work just spoken of. The utilized capacity of production centres passes into the ordinary cost of the work, the unutilized or wasted portion flows into the supplementary rate, and becomes a memorandum of the inefficient conditions prevailing. A high supplementary rate represents wasted opportunities and nothing else; its expression as a percentage on work is only a matter of convenience, for the purpose of a danger signal. It consists, in fact, of that portion of the indirect charges which, if not dealt with in this way, would remain to the debit of profit and loss account. Either as part of costs or as a balance on the wrong side in the accounts, it signifies unemployed capacity for production. It is distributed over work done

only because its significance is more easily recognized in that way than if it were left as an undistributed debit balance. Further, it is thus brought to the notice of officials who have no access to the accounts.

If there is one thing more than another that seems to require emphasizing at the conclusion of this book, it is the need of regarding costs as having an intimate and vital relation to the financial accounts. The requirements of accountants and of technical officials differ so much that each is apt to go on his own way and pay little attention to the other's work. As a matter of fact, costs can be more intelligently understood, particularly as regards their relations with indirect charges, if they are regarded as the separate items from which the financial accounts are built up. To speak technically, the latter are the control accounts and the former are the detail accounts which ought to correspond completely and absolutely. The doctrine of unemployed capacity set out above has been developed not from the shop side, but from a review of the elements of profit and loss. During this examination it was observed that where charges due to the activity of production centres were alone made part of costs, a

considerable balance remained if the shops were not employed to their full capacity. That this balance represented wasted capacity of production *and was in fact the price paid for that waste* was presently seen. This instance is given to show how pure accountancy can be made to throw light on manufacturing problems, for it is certain that a study of costs as costs would never have brought this important fact to light.

Lastly, emphasis must be laid on the fact that there can be no such thing as "simple" systems of cost. There cannot be less than five elements in any true cost, all of which must be expressed separately. (1) Materials; (2) Direct Labor; (3) Machine Rate (which expresses in one figure a number of different and independent incidences); (4) Supplementary Rate, expressing wasted or unemployed capacity; (5) Selling Expense. It is hoped that the arguments put forward in this volume will have served to demonstrate that these five elements have no common ground and cannot therefore be expressed in any other way than quite independently of each other. Any other method must produce figures that are necessarily unreliable, and unsafe.

THE END

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